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APPLEBY'S HANDBOOK OF MACHINERY

SECTION 3.

PUMPING MACHINERY.

Mechanisms

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APPLEBY'S ILLUSTRATED HANDBOOK OF MACHINERY.

SECTION III.—PUMPING MACHINERY,

INCLUDING

PUMPING ENGINES, CENTRIFUGAL, STEAM AND
HAND PUMPS.

WITH

PRICES, WEIGHTS, MEASUREMENTS, AND SOME DATA ON WORKING EXPENSES AND RESULTS OBTAINED.

BY

C. J. APPLEBY,

OF

(APPLEBY BROS.)

EMERSON STREET, SOUTHWARK, LONDON, S.E.

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THE Edition of APPLEBY'S HANDBOOK OF MACHINERY, published in 1869, and several reprints of it having been exhausted, a New Edition (of which this section forms a portion) is now being completed; and for the convenience of those who desire information on specific subjects, but not on all those treated, the book will be divided into eight sections, each of which may be obtained separately as follows:—

SECTION 1.—PRIME MOVERS.

STEAM, GAS AND AIR ENGINES, BOILERS, TURBINES, ETC.

SECTION 2.—HOISTING MACHINERY.

WINDING ENGINES, HYDRAULIC, STEAM AND HAND CRANES, WINCHES AND JACKS.

SECTION 3.—PUMPING MACHINERY.

PUMPING ENGINES, CENTRIFUGAL, STEAM AND HAND PUMPS.

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INCLUDING THE MACHINERY AND MATERIALS REQUIRED FOR THE CONSTRUCTION AND EQUIPMENT OF RAILWAYS AND OTHER PUBLIC WORKS.

SECTION 6.—COLONIAL AND MANUFACTURING MACHINERY.

FOR TREATING CORN, COFFEE, RICE, SUGAR, COTTON, AND OTHER PRODUCTS, OIL MILLS, GAS WORKS, ETC.

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The subject matter has been almost entirely rewritten, and the Engravings illustrate for the most part work designed or carried out by the Authors' Firm, and now in successful operation. Details of design, construction, and proportions will be subject to modification from time to time.

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The details above referred to are in a handy form for reference, and it is hoped they may prove useful alike to Engineers and to users and purchasers of Machinery and Materials connected therewith.

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SECTION III.

PUMPING MACHINERY.

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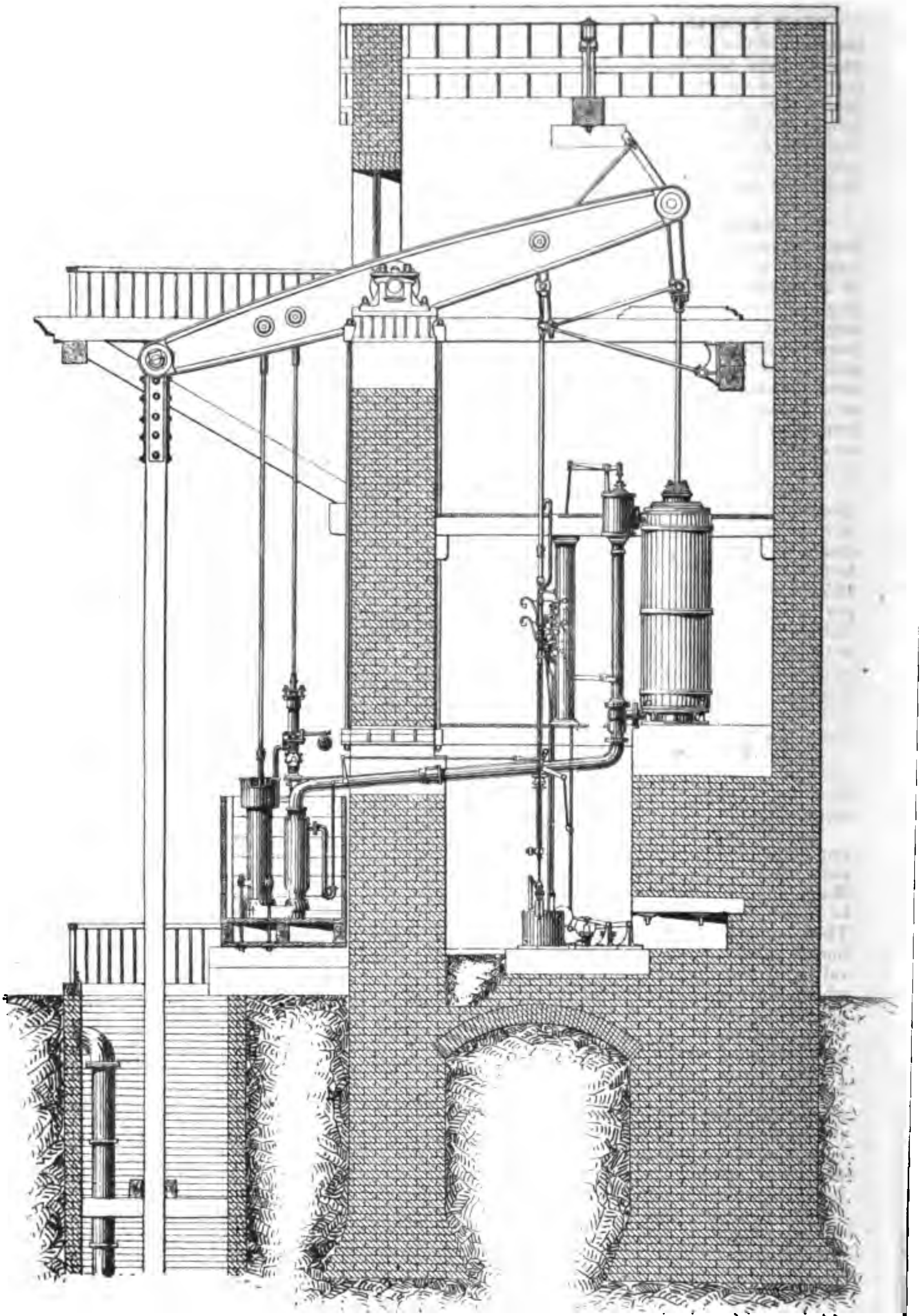

Fig. 251.

BEAM PUMPING ENGINES. The first steam engines introduced by Watt for pumping large quantities of water from mines, or for the supply of towns, are known as Watt's single-acting engine; and although engines of this form are not now made, they have given excellent results, and many of them are still at work. A good specimen of the single-acting pumping engine was erected at the Chelsea Waterworks by Boulton and Watt, for forcing water to a height of 130 feet; the steam cylinder had a diameter of 48 inches, and the lifting pump a diameter of 17½ inches, both being 8 feet stroke. The consumption of fuel averaged 7.3 lbs. per hour for each horse-power, a result which compares not very unfavourably with many engines of far more recent date.

The **CORNISH PUMPING ENGINE** does not differ very widely from Watt's engine; but the introduction of a higher pressure of steam, and an increase in the ratio of expansion, has naturally been followed by very economical results; the Chelsea engine only attained a duty of 22,800,000 foot pounds for each bushel of coals consumed, whilst some of the best Cornish engines have reached an efficiency of 90 or 100 million foot pounds. Although the Cornish engine has, to a great extent, been superseded by various forms of rotative engines, it has not been surpassed in durability—engines of this class after working for fifty or sixty years being still in operation and doing good duty. The valve gearing of the Cornish engines is so arranged that it is easily adjusted to suit variations in the work required by cutting off steam at a greater or less portion of the stroke, so that under a sudden emergency, the work performed by the engine can be increased by merely re-adjusting the valve gear; or, in the case of an engine for supplying a town with water, the power may be varied to suit the requirements of an increased population, &c.

It should not be forgotten, however, that this increase of power is accompanied by a corresponding falling off of economy in consumption of fuel, for it was ascertained by Mr. Wickstead in some experiments made on a Cornish engine at the East London Waterworks, that when steam was cut off at six-tenths of the stroke, a duty of 76,700,000 foot pounds was obtained from 112 lbs. of coal, whilst when the steam was cut off at three-tenths, the duty rose to 105,700,000. In these experiments the initial pressure in the cylinder varied from 15 to 20 lbs. per square inch. In Cornish engines every precaution is taken to prevent loss of heat by radiation, the cylinders are steam-jacketed, lagged, and felted, the steam pipes are coated with non-conducting materials, and the care exercised in this direction and the high grade of expansion, contribute very largely to the excellent results above referred to, for the boilers used in conjunction with the Cornish engine are usually by no means of the most economical form. In most Cornish engines, though not in all, one end of the main lever or beam is longer than the other, in order that the steam piston may have a higher velocity than the pump piston.

Many beam pumping engines are made on the compound system, somewhat similar to that shown in Fig. 1, Section 1. The force of the steam is more evenly transmitted, and the cost of the extra cylinder is to some extent compensated by the beam and other parts being lighter, and a slight increase in working economy is due to the more even temperature of the cylinders.

The introduction of the fly-wheel with its crank and connecting-rod, effected a considerable improvement in the beam pumping engine by limiting the length of the stroke, and thus reducing the risk of accidents; it also acts as a governor to equalise the power developed. Many engines of this class are employed by waterworks companies, amongst which may be mentioned those erected by Messrs. Boulton and Watt for the New River Company. These engines each drive a pump of the ram and bucket form. The peculiarity of the ram and bucket pump consists in the introduction of a plunger or ram into the ordinary lift pump, with valves in the bucket. On the down stroke half of the water is delivered by the plunger, whilst the remaining half is delivered by the bucket on the up stroke; thus, a continuous delivery of water is effected by a pump which need have only two valves, although usually there is a third in the delivery pipe, called the "retaining valve"; pumps of this construction give very good results.

The beam pumping engine, Fig. 251, constructed by Messrs. Appleby, by order of Sir C. Fox and Sons, for draining the Bateas Mine in Chili, has successfully performed its work for several years past. The steam cylinder is 20 inches internal diameter, steam jacketed, and the stroke is 7 feet; the covers are also steam jacketed, the upper one being provided with an extra long piston rod gland. The piston is formed of two cast junk rings bolted together, and fitted with metallic rings and springs; the piston rod is turned taper at one end and cottered into the piston, the other end being cottered into the crosshead.

The parallel motion is of the usual form, all the rods are made of wrought iron, and the moving ends fitted with gun-metal bearings and cotters for taking up wear. The gudgeon at the cylinder end of beam to which the main links are connected is of wrought iron; the beam is very light, strong, and neat in construction, being formed of two wrought-iron plates stiffened by angle irons facing outwards, and the plates are held together by distance pieces and bolts. The bosses for the various gudgeons are rivetted to each beam; the pump gudgeon and steam-cylinder gudgeons are respectively 10 feet 4 inches, and 12 feet from the main or rocking centre, so that the pump has a stroke of 6 feet, and the steam piston 7 feet. The main gudgeon is of wrought iron, and the journals work in massive blocks fitted with adjustable gun-metal bearings. At the cylinder end of the beam is fixed a wrought-iron crossbar, which would strike against the main girders carrying the beam, if the piston were to overrun its proper stroke, and thus prevent a serious breakdown.

Exception may be taken to the wrought-iron beam, on the ground that it is not heavy enough to absorb the great power of the steam piston at the beginning of each stroke, and thus prevent shocks; but this objection is removed by the introduction of heavily weighted balance bobs on the pump rods; these bobs not only balance the surplus weight of the pump rods, but add to the total mass the inertia of which has to be overcome each time the motion of the beam is reversed, and thus to a certain extent perform the duty done by the fly-wheel in rotative engines. The air pump and feed pump are both driven from the beam. The main pumps are of the class generally used in Cornwall and elsewhere for the drainage of mines; the lower or lift pump delivering into a small cistern from which the upper or force pump takes its water. The speed of the engine is regulated by a cataract in the usual manner.

This engine, together with a pair of horizontal winding engines (see p. 109, Section 2,) by the same makers, were supplied with steam from three Cornish boilers 30 feet long, 6 feet diameter, each with one internal flue 3 feet diameter, provided with the usual fittings, including safety, stop, feed, scum, and blow-off valves, expansion joints in the steam pipes, &c. A Cornish engine similar to that above described and illustrated by Fig. 251, with 50 fathoms of pumps, is worth about £820, and the weight is about 30 tons.

Figs. 252 to 254, illustrate some details connected with Cornish engines and pumps.

CAST-IRON BEAM. Many engineers who have had experience in the working of Cornish engines. consider that a heavy cast-iron beam of the type most in use causes the engine to work steadily and prevents the occurrence of sudden shocks: in fact, Mr. Marten states that of two engines exactly alike, excepting in the construction of their beams, that with the heavier beam gave considerably the higher duty; however, as has been hinted before, it is possible to introduce fly-wheels, or bob-balances to perform similar services. At the Kew Waterworks a Cornish engine with 100 inches steam cylinder has a beam in two pieces, weighing in all 40 tons; and many very massive beams may be seen in all parts of the world. The price of these beams may be taken at £12 per ton.

DRAWING AND PLUNGER LIFTS. Fig. 252 shows the former, and includes a working barrel about 11 feet long, a door piece about 6 feet long, fitted with valve seat and valve, an egg-ended windbore 9 feet long, and two bucket springs. The door piece in the foreground has lugs for suspending it when the valves have to be examined. The plunger lifts are usually fixed above the drawing lifts, and the prices include H and door piece (of which Fig. 253 is an enlarged engraving), plunger case with stuffing box and brass bushed gland, plunger 9 feet stroke, valve and valve seats, and all the necessary bolts.

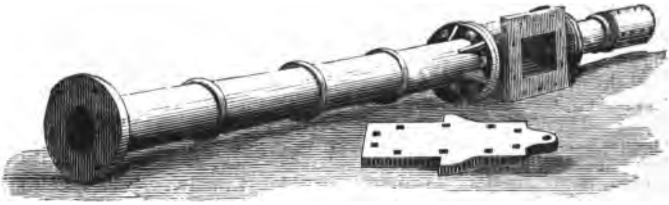

Fig. 252.

PRICES OF DRAWING AND PLUNGER LIFTS.

Diameter of barrel or plunger in inches	6	9	12
Price of drawing lift, Fig. 252	£25	£42	£53
Approximate weight of ditto in cwts.	32	50	66
Price of plunger lift	£40	£62	£80
Approximate weight of ditto in cwts.	40	68	95

The above prices do not include any pipes, or, as they are called in the mining districts, "pumps," nor the bob or pump rods. The cost of these is given in the subjoined lists for 6" and 8" pumps for depths varying 150 to 600 feet, with all accessories ready for fixing in the mines, also the approximate weights of the various parts for each depth.

PRICE LIST OF 6-INCH PUMPS FOR 150 TO 600 FEET.

Depth in feet	150	300	360	450	600
Price of 6-inch pumps	£170	£285	£322	£416	£500
Weight of 6-inch ditto in cwts.	180	310	356	450	566
Price of suitable working bob lever ...	£54	£95	£105	£130	£180
Weight of ditto in cwts.	30	64	70	92	131

PRICE LIST OF 8-INCH PUMPS FOR 150 TO 600 FEET.

Depth in feet	150	300	360	450	600
Price of 8-inch pumps	£216	£372	£422	£536	£662
Weight of ditto in cwts.	234	409	460	600	740
Price of suitable bob lever	£60	£100	£110	£140	£210
Weight of ditto in cwts.	32	70	75	110	145

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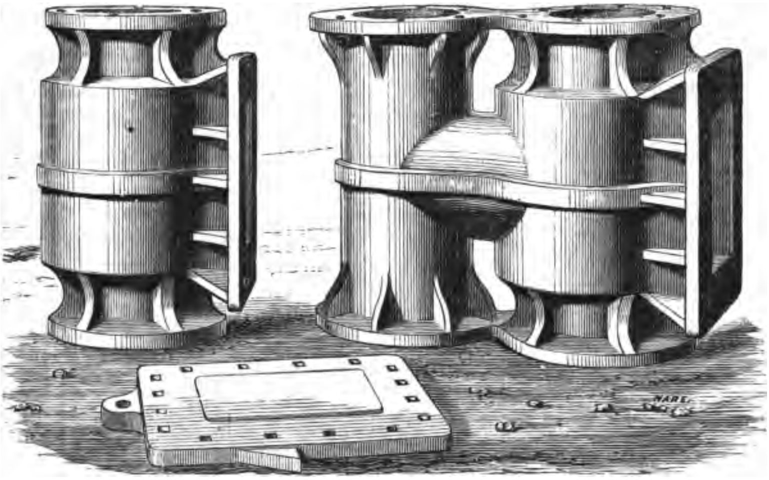

Fig. 253.

H PIECES AND DOOR PIECE, Fig. 253. These portions of mining pumps are made with the flanges no larger in diameter than is absolutely necessary: they are very thick, and are usually strengthened by brackets between each pair of bolt holes; the door faces are planed and flanges turned and faced. Surplus length in the working barrels of pumps for mine work (beyond that actually required by the piston or plunger and its stroke), should be provided to obviate the necessity of nice adjustment of rods; this saves much time, trouble, and expense.

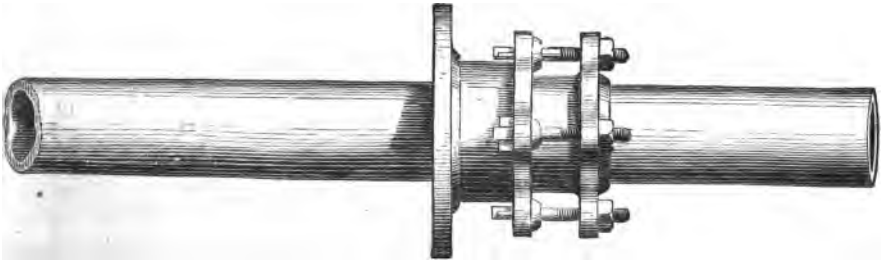

Fig. 254.

PLUNGER POLE, STUFFING BOX, AND GLAND, Fig. 254, as used in deep mines, are illustrated, because being subject to much wear, they require replacing more frequently than some other parts; the average value is about £10 per ton.

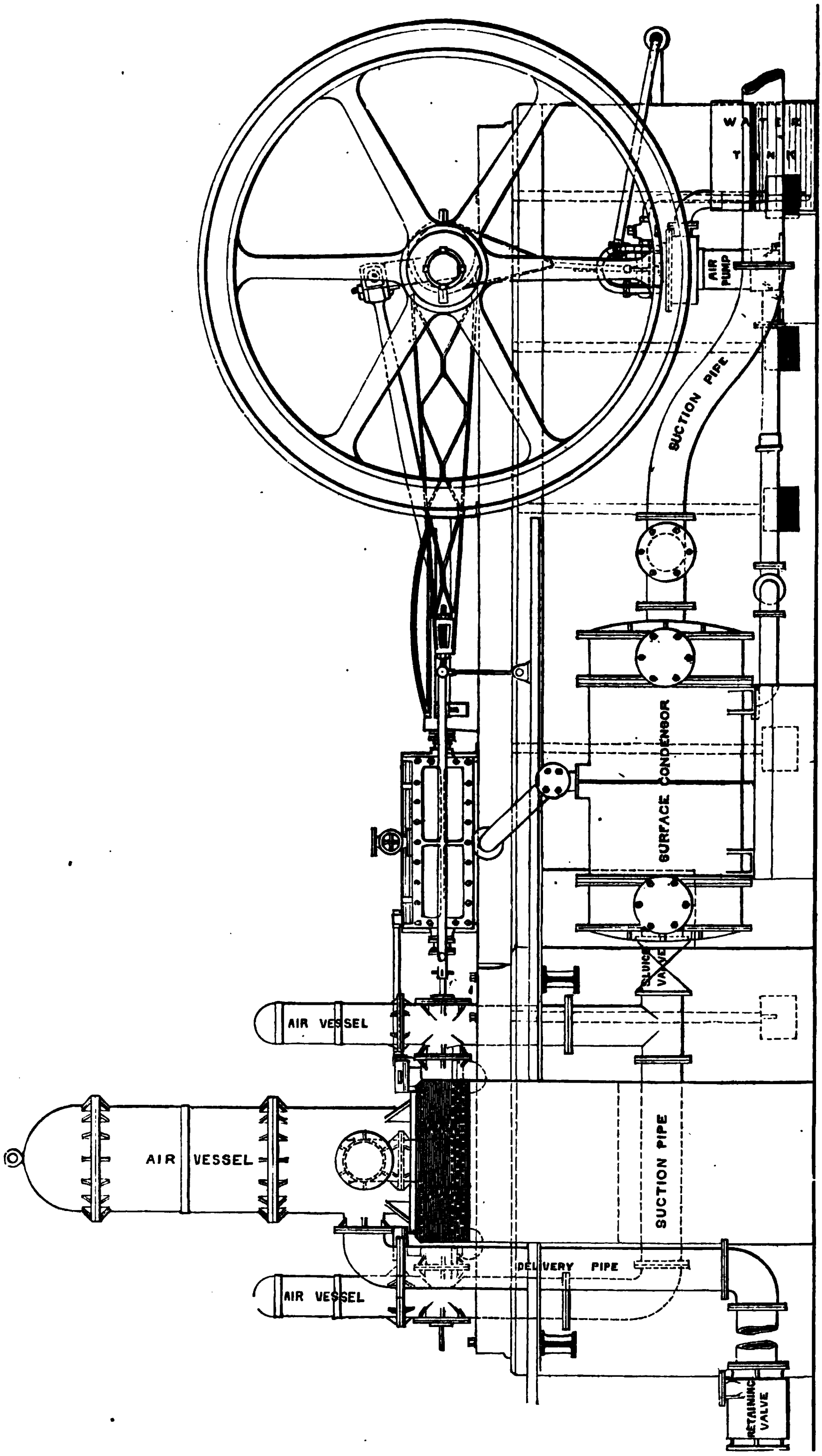
WATER TANK
AIR PUMP
SUCTION PIPE
SURFACE CONDENSOR
SLUICE VALVE
AIR VESSEL
AIR VESSEL
SUCTION PIPE
DELIVERY PIPE
AIR VESSEL
RETAINING VALVE

Fig. 255.

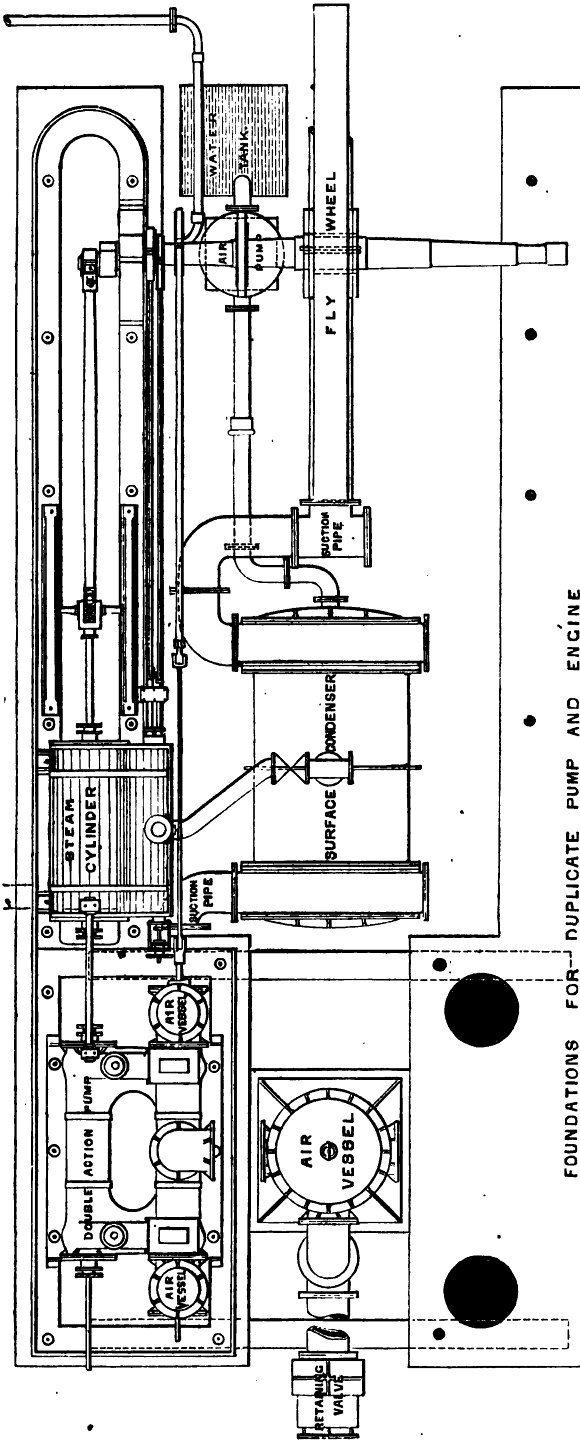
WATER TANK
AIR PUMP
FLY WHEEL
SUCTION PIPE
STEAM CYLINDER
SURFACE CONDENSER
SUCTION PIPE
AIR VESSEL
DOUBLE ACTION PUMP
AIR VESSEL
AIR VESSEL
RETAINING VALVE
FOUNDATIONS FOR DUPLICATE PUMP AND ENGINE

Fig. 256.

In ordering separate parts of machinery, it is essential that all dimensions and full particulars should be carefully given, accompanied, if possible, by a detailed drawing; this enables the manufacturer to supply what is wanted, and often saves much trouble and inconvenience. Prices of pipes suitable for use in mines will be found at pages 148 to 154.

HORIZONTAL PUMPING ENGINES, Figs. 255 and 256. The high first cost of Cornish pumping engines very frequently precludes their adoption, and this form of engine is efficient in working, occupies much less space, and costs less both for machinery and foundations. Many engines of this class have been erected by the Author's firm for irrigation and town supply; the subjoined being selected as examples are described in detail.

The engine, Figs 255 and 256, was erected by the Author's firm for supplying water to the town of Louth. It will be seen on reference to the engravings, that arrangements are made for a duplicate engine, if at any future time the demand for water should exceed the capabilities of the single engine already erected.

The steam cylinder is 20 inches in diameter, and 4 feet stroke; it is cast of the best grey iron in one piece with its valve chest, and is felted and lagged with mahogany to prevent the loss of heat by radiation.

The valve gear consists of two valves, both driven by means of eccentrics on the crank shaft, the main or D valve, and the expansion valve working on the back of the D valve. Both have a stroke of 4¼ inches, and the expansion valve is capable of being adjusted, by altering the angle of its eccentric relatively to the angle of the main eccentric, to cut off the admission of steam to the cylinder at any point of the stroke from one-tenth to eight-tenths. A high rate of expansion is, of course, a most effective means of economising fuel, but considerable difficulty is experienced in overcoming the inertia of the column of water in the rising main when the engine is first started. As it would be inconvenient to adjust the eccentric each time the engine was set to work, a very simple arrangement is adopted to overcome the difficulty at starting above referred to. The expansion valve, instead of being driven directly by its eccentric rod, is connected to it by means of a simple pawl catch; when the engine is started, this pawl is thrown off the eccentric rod on to the main valve spindle (between collars specially provided). The expansion valve then simply travels with the main eccentric and steam is admitted for eight-tenths of the entire stroke; after one or two strokes the pawl is thrown back into its own eccentric rod, and the engine works at its ordinary grade of expansion.

The work to be done by a pumping engine is generally so nearly uniform, that it is unnecessary to provide governors or an automatic expansion gear; but in cases where the head to be pumped against varies very much, a steam regulator valve is supplied, which is self-adjusted by the pressure in the delivery main. Such regulators are extremely useful in case any part of the delivery main should burst, as the diminished head is immediately followed by a correspondingly diminished supply of steam, and the engine is prevented from running away. A regulating valve of this description was applied to this engine. The steam piston is of the ordinary form with cast-iron junk rings, metallic rings, and springs.

The cross-head is cottered to the piston rod, and is of wrought iron, having a forked jaw to receive the end of the connecting-rod. The gudgeon is of wrought iron, and is three inches in diameter at the centre, where it passes through the cross-head and connecting-rod, and 2¼ inches at each end, where it enters the guide blocks. These guide blocks are of cast iron, of ample length, and work between planed guide bars, the bottom bars being recessed to form oil reservoirs. The connecting-rod is of wrought iron, 4½ inches in diameter at the centre, 3¼ inches in the neck at the crank end, and 2⅜ inches at the cross-head end. The crank end of the connecting-rod is forged solid, and fitted with gun-metal bearings, 6½ inches wide, bored 4¼ inches, and adjusted by a taper cotter. The cross-head end of the rod is formed by a wrought-iron strap, gib and cotter, fitted with gun-metal bearings, 4¼ inches wide, bored 3 inches. The crank pin is of wrought iron, 4¼ inches diameter, 6½ inches long in the journal. The centre of the existing engine would be 13 feet 6 inches from the centre of duplicate engine.

The crank shaft is of wrought iron, 7 inches in diameter in the disc plate, 6½ inches in the necks, and 11 inches in the centre, where the fly-wheel is keyed on. The plummer blocks for crank shaft are fitted with gun-metal bearings, 10 inches long, bored 6½ inches. The fly-wheel is 14 feet diameter, cast in halves, the two parts being connected at the rim by dowels and cotters, and at the boss by wrought-iron rings shrunk on. The rim of this fly-wheel weighs 5½ tons. The surface condenser used with this engine consists of a cylindrical casting, 4 feet 4 inches in diameter, and about 8 feet long, divided into three compartments, the largest being in the centre; this is 5 feet 5 inches long, and is traversed by 211 wrought-iron tubes, 1$\frac{13}{16}$ inches in diameter, which connect the outer compartments. The exhaust steam from the cylinder is conducted by pipes to the central compartment and circulates round the outside of the small tubes, whilst the water on its passage to the main pump passes through the tubes; the condensed steam, &c., is then pumped out by the air pump, and delivered into the hot well, from whence the water is taken to feed the boilers. The air pump, as shown in engravings, is directly beneath the crank shaft. The bucket is driven by an eccentric, and has a stroke of 8 inches and a diameter of 12 inches. The main pump is placed directly behind the steam cylinder and is bolted to the same bed-plate; the pump piston rod is a continuation of the steam piston rod, so that the power is transmitted in the most direct manner possible. This pump has a diameter of 12 inches, and a stroke of 4 feet, so that running at 30-stroke per minute, it is capable of delivering 70,000 gallons per hour. The valves for this pump are in equilibrium, and are actuated by an eccentric on the crank shaft. Close to the pump is a main air vessel, 3 feet diameter and 12 feet high, in addition to two smaller vessels placed over the suction inlets of the pump. A retaining valve is placed near to the air vessel, which prevents the possibility of any water leaking back through the pumps when the engine is stopped, and also admits of the pump being examined; this retaining valve, however, is only provided as an additional means of security, as there is a sluice valve between the pump and air vessel. The water is delivered at a pressure due to a height of 170 feet. The steam for this engine is generated in a Cornish boiler 6 feet diameter, 25 feet long, with an internal flue 3 feet in diameter, the boiler being provided with all the usual mountings, including safety, stop, feed, and blow-off valves.

An engine, very similar to the foregoing in design and proportions, was erected by the Author to irrigate an estate of upwards of 5,000 acres. The water is drawn from the Thames and pumped into a reservoir, which is about 80 feet above the river. Like the Louth engine, it has a surface condenser, and the arrangement admits of a duplicate engine being fixed in the same house, and connected with the same condenser, air vessel, and crank shaft.

At another waterworks, where the duty required was 100,000 gallons delivered to a height of 170 feet in a day of 10 hours, the engine is very similar to those described above; but the dimensions and arrangements are somewhat modified to suit different conditions. The water is obtained from a well about 47 feet deep, but the water level is usually within a few feet of the surface. The water is lifted from the well by a pump of the ram and bucket class, the bucket is 7½ inches diameter, having a stroke of 2 feet, into a tank fixed outside the engine house, from which it flows into a horizontal double-acting force pump, 5½ inches diameter and 20-inch stroke. The steam cylinder to drive these pumps is 10 inches diameter, 20 inches stroke, and is fixed directly in front of the force pump and on the same base-plate. The valve gear for the steam cylinder differs materially from that at Louth, and is of the form known as Myer's expansion gear. The main valve and the expansion valves are both driven in the usual manner by eccentrics on the crank shaft. The moment at which the steam supply is cut off from the cylinder is altered by adjusting the distance between the two expansion valves. This adjustment is obtained by means of right and left handed screws, actuated by a hand-wheel outside the valve box, so that the valves can be altered whilst the engine is running. The steam can be admitted during one-tenth or any portion of the stroke up to eight-tenths, and when the engine is started the valves are quickly arranged to admit steam for the greater part of the stroke, and as readily adjusted to their usual working position when the inertia of the column of water in the rising main has been overcome. There is a retaining valve on the rising main near to the air vessel.

A surface condenser is used, and the air pump is a horizontal plunger pump, 6½ inches in diameter, with a stroke of 6½ inches. The steam is obtained from two Cornish boilers, 14 feet long and 4 feet 3 inches diameter, with internal flues, 2 feet 3 inches diameter; furnished with the usual mountings, including safety, stop, feed, and blow-off valves, expansion joint on the steam pipe between the boilers, &c. The price of an engine, pump, and condenser, &c., complete, similar to that last described, is £500; or, for the engine and two boilers, weight about 20 tons, £900.

The price of an engine similar to the one at Louth, weight about 20 tons, is £850; or, the engine and one suitable Cornish boiler, weight about 35 tons, £1,500. The cost of packing for shipment and delivery free on board, London, is about 5 per cent.

It is frequently desirable at waterworks for the supply of towns, to provide an engine to be used in case of an accident to the principal engine; for this reason, an exact duplicate is frequently put down long before the demand necessitates both engines running at once. This plan, no doubt, has its advantages, but it is considerably more costly than providing a small high pressure engine taking steam throughout nearly the whole stroke, and capable in such an emergency of keeping the town supplied by running night and day. A very small engine will generally fulfil these conditions, and as it has only to be used for a short time at long intervals, when the main engine is undergoing repairs, its low first cost more than compensates for the want of economy in consumption of fuel.

PUMPING ENGINE, Fig. 257, fulfils conditions differing from those last described, and was designed and made by the Author's firm for supplying water to the town of Ipswich, Queensland.

The specification issued by the Government of Queensland, on which several engineers were invited to furnish designs and tenders, stated, that the machinery must deliver 30,000 gallons of water per hour, through rather more than two miles of main pipe, to a total height of 241 feet; the source of supply being a well 77 feet deep, the water level varying through a range of 55 feet. The machinery to be as simple and substantial as possible.

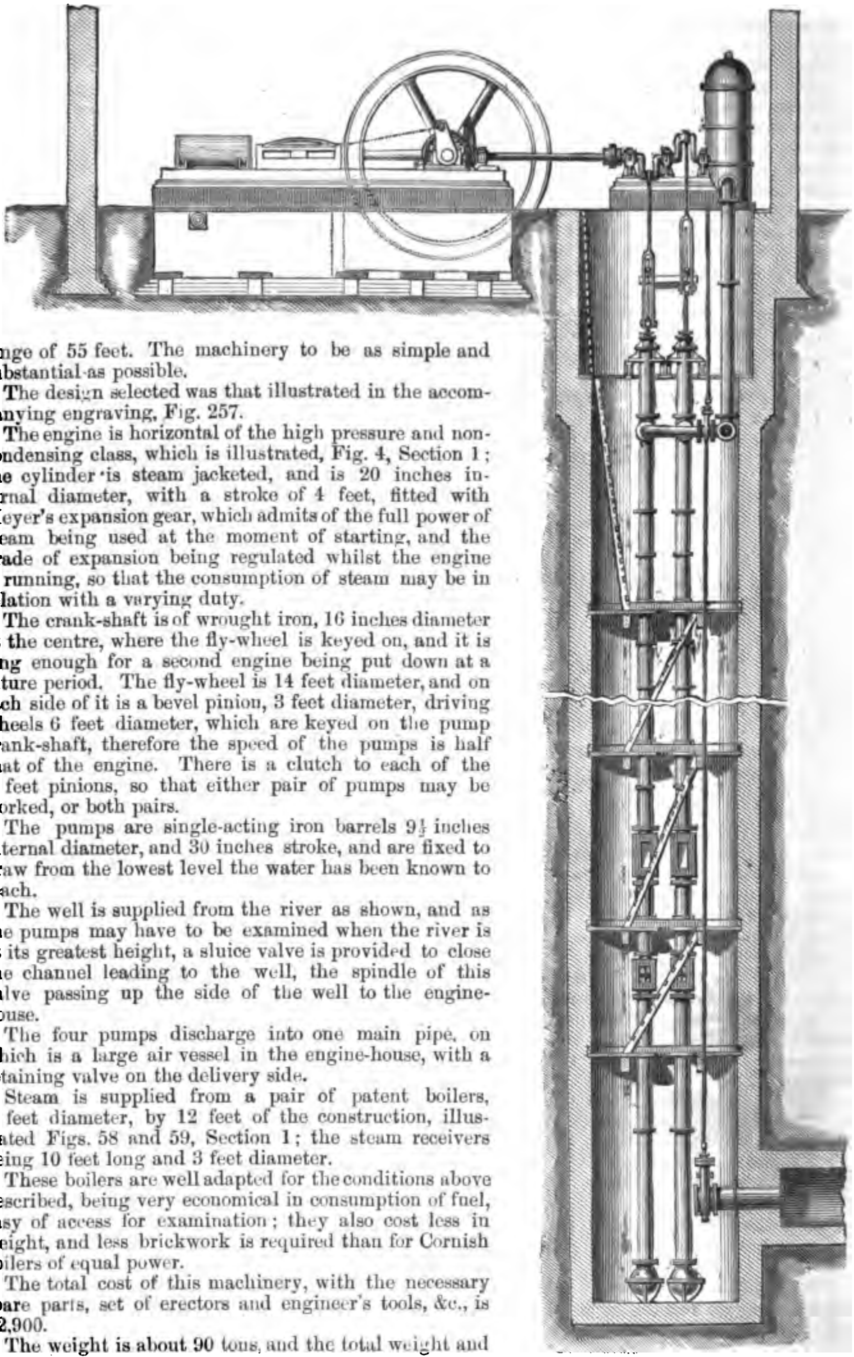

Fig. 257.

The design selected was that illustrated in the accompanying engraving, Fig. 257.

The engine is horizontal of the high pressure and non-condensing class, which is illustrated, Fig. 4, Section 1; the cylinder is steam jacketed, and is 20 inches internal diameter, with a stroke of 4 feet, fitted with Meyer's expansion gear, which admits of the full power of steam being used at the moment of starting, and the grade of expansion being regulated whilst the engine is running, so that the consumption of steam may be in relation with a varying duty.

The crank-shaft is of wrought iron, 16 inches diameter at the centre, where the fly-wheel is keyed on, and it is long enough for a second engine being put down at a future period. The fly-wheel is 14 feet diameter, and on each side of it is a bevel pinion, 3 feet diameter, driving wheels 6 feet diameter, which are keyed on the pump crank-shaft, therefore the speed of the pumps is half that of the engine. There is a clutch to each of the 3 feet pinions, so that either pair of pumps may be worked, or both pairs.

The pumps are single-acting iron barrels 9½ inches internal diameter, and 30 inches stroke, and are fixed to draw from the lowest level the water has been known to reach.

The well is supplied from the river as shown, and as the pumps may have to be examined when the river is at its greatest height, a sluice valve is provided to close the channel leading to the well, the spindle of this valve passing up the side of the well to the engine-house.

The four pumps discharge into one main pipe, on which is a large air vessel in the engine-house, with a retaining valve on the delivery side.

Steam is supplied from a pair of patent boilers, 6 feet diameter, by 12 feet of the construction, illustrated Figs. 58 and 59, Section 1; the steam receivers being 10 feet long and 3 feet diameter.

These boilers are well adapted for the conditions above described, being very economical in consumption of fuel, easy of access for examination; they also cost less in freight, and less brickwork is required than for Cornish boilers of equal power.

The total cost of this machinery, with the necessary spare parts, set of erectors and engineer's tools, &c., is £2,900.

The weight is about 90 tons, and the total weight and measurement is 130 tons.

VERTICAL PUMPING ENGINES. The pumping engine illustrated by Fig. 258 was designed for supplying water at large or terminal stations, extensive factories, or small towns and villages. It was originally constructed for the New South Wales Railway Stations, and was calculated at 27 strokes per minute, to raise 2,500 gallons per hour to a height of 300 feet; but the proportions can be modified to an almost infinite extent, and it may be worked up to 40

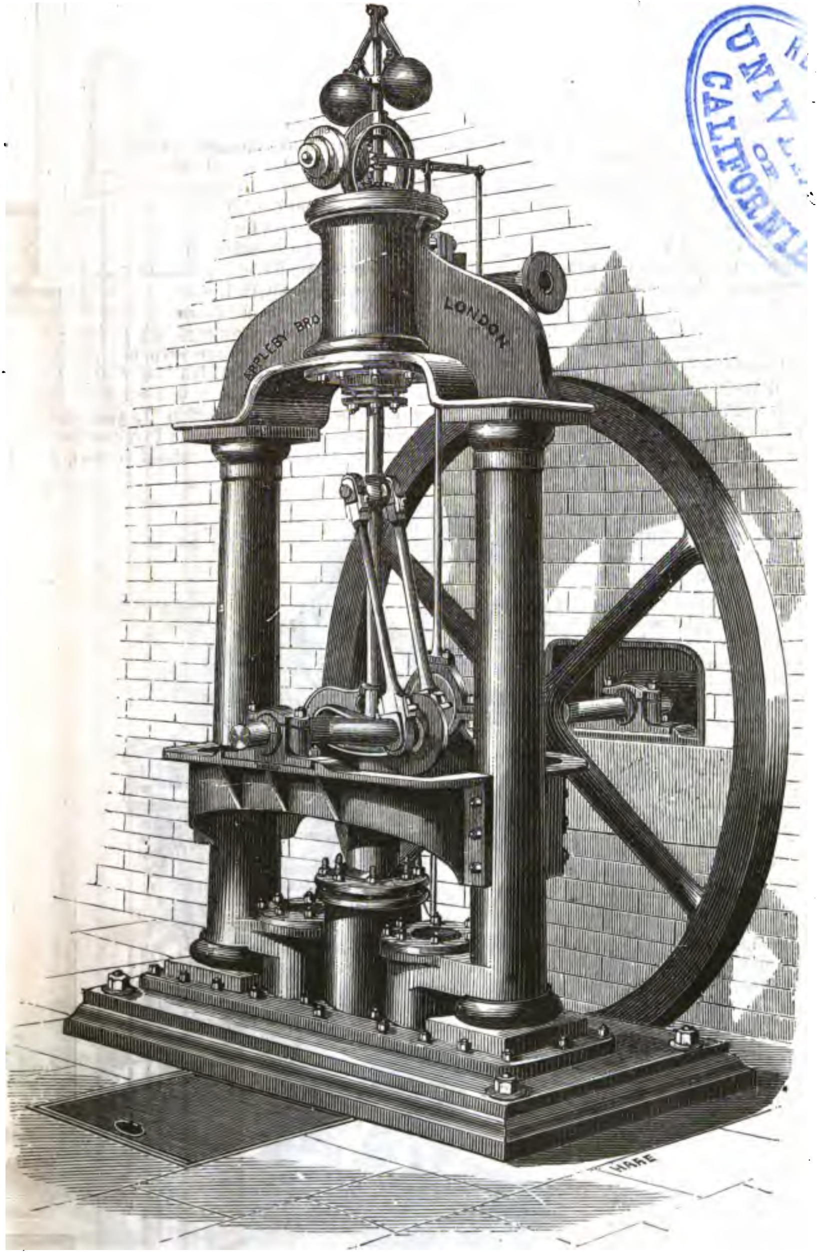

Fig. 258.

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strokes per minute. When the water is within 25 feet of the surface, the pump is fixed directly over the well on the engine base-plate as shewn; but for use in deep wells it is placed at any convenient depth below, and the pump rod carried down through the base-plate. The pump is on the ram and bucket principle, worked direct from the piston-rod; the engine illustrated has a bucket 7 inches in diameter and a ram 5 inches diameter, with a stroke of 13 inches; the steam piston being 9½ inches diameter, and of the same stroke as the pump. The suction, bucket, and delivery valves are gun-metal circular grids, with india-rubber discs, and the two columns supporting the cylinder are used as air vessels for the suction and delivery. The bucket and working barrel of the pump are below the base-plate, and covers are provided to the suction and delivery valves for examination and repairs. The crank and connecting-rods are of wrought iron, and the whole of the bearings and glands are of gun metal, and adjustable. The eccentric which works the slide valve, also drives a small hollow plunger feed pump placed on the base-plate behind the pump. This is not seen in the engraving. The governors are on the top cover of the steam cylinder, and are fitted with cone gut pulleys for driving at variable speeds, throttle valve, and levers; small high speed governors can be substituted for these, but as has been before mentioned, the work on a pumping engine is usually so regular, that governors are not required. A heavy fly-wheel is keyed on to the crank-shaft, the end of the shaft being carried by a plummer block in a wall box, or, if more convenient, a plummer block is fixed on a short stand, or brick-work pier. The whole is mounted on a strong cast-iron base-plate, in which the delivery passages are cast, a flanged connection being made with the pipes on the underside of the plate. The steam for this engine is taken from a Cornish boiler 10 feet long by 3 feet 6 inches diameter, but when the space available is limited, a vertical boiler may be adopted. Particulars of every class of boiler will be found in Section 1, pages 54 to 64. The price of such an engine with a Cornish boiler of the size given, and all connection (boiler not more than 20 feet from engine), is £230. The total weight is about 6 tons, and the cost of packing for shipment, 5 per cent.

VERTICAL ENGINE WITH DOUBLE-ACTING LIFT AND FORCE PUMP. When a large supply of water is required in situations where power cannot be easily obtained from an existing engine, or where a large engine is only running the usual working hours, whilst the water supply must be continuous, this compact arrangement may be usefully employed. It has been used for well-sinking, as well as for the water supply of Paper Mills, Tanneries, Breweries, Railway Stations, and similar establishments. The steam is brought from a boiler in any convenient position to the steam cylinder, which is at one end of the base-plate, the pump being secured to the other end; and where the pump is used as a Fire Engine, or Boiler Feed pump, or for forcing to a great height, the central column forms a capacious air vessel as well as carrying the shaft bearings. The crank-plate is made extra large to act as a fly-wheel, and is balanced, and the engine and pump are got up in the best style. In order to make the engine available for other

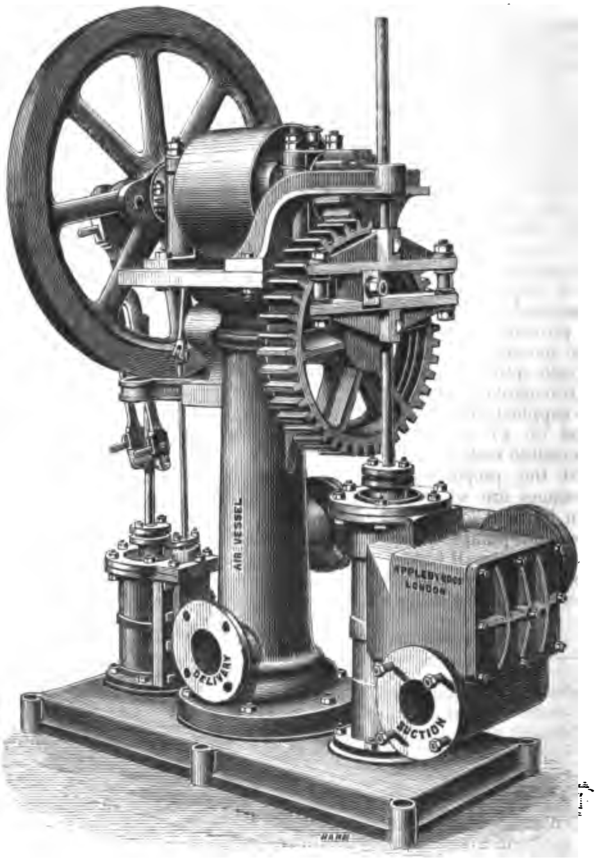

Fig. 259.

purposes than pumping, a pulley is keyed on the crank shaft for transmitting the power by a leather band. The arrangement shown is for wells not exceeding 20 to 25 feet deep; but where the water is a greater depth from the surface, the pump is fixed in the well, and the pump rod passes through the base-plate.

PRICES OF VERTICAL ENGINE AND PUMP, Fig. 259.

Diameter of steam cylinder in inches	4	4½	5	5½	6	6½
Diameter of pump in inches	3	3	4	5	6	8
Length of stroke in inches	9	12	9	12	12	14
Gallons per hour at 40 stroke per minute ..	1000	1350	1800	2500	5250	11·500
Price	£50	£55	£65	£75	£85	£110
Approximate weight in cwts.	16	17	25	30	35	40

DIRECT-ACTING VERTICAL STEAM PUMPS, Fig. 260. The frame casting consists of one hollow column, branching out into brackets at the top to which the steam cylinders are fixed, and spreading out at the bottom in an arched form, as shown in the engraving; the base-plate is cast in one with the rest of the framing, and strong lugs are provided for the foundation bolts. The pumps are simple ram pumps, the plungers being fixed directly to the steam piston rods. The steam cylinders are inverted and bolted to the brackets before mentioned, the valve boxes are placed with the covers outward, so as to be easy of access. The crank shaft is of hammered scrap iron immediately beneath the pumps, and is driven from the piston rods by means of bow or kite connecting-rods. The position of the crank shaft permits the employment of extra long connecting and valve rods. The pump plunger and steam piston form excellent guides for each other. The bearing surfaces throughout are large, and the machine will run a long time with but little attention or repair. A heavy fly-wheel is provided on the crank shaft to equalize the motion; otherwise, the pumps being single acting would cause the engine to run irregularly. If desired, governors can be supplied with the engines at an increased cost of £7 to £12. All the parts are accessible both for oiling and examination, and the proportions of the valves and passages are so ample that these pumps can be used for tar or other thick liquids; also for pumping water from collieries, supplying small towns, factory or station tanks, for feeding boilers, or as fire engines. When not constantly required for pumping, the engines may be utilized for driving machinery, the power being taken by a strap from the fly-wheel.

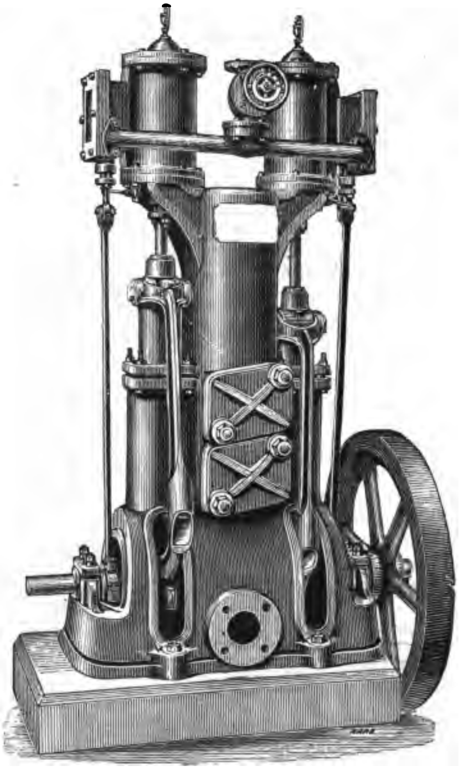

Fig. 260.

PRICES OF SINGLE-ACTING PUMP, WITH ONE RAM AND ONE CYLINDER.

Diameter of ram in inches ..	2	2½	3	3½	4	4½	5
Length of stroke „ ..	4	5	6	7	8	9	10
Number of strokes per minute ..	180	144	120	103	90	80	72
Gallons pumped per hour ..	475	750	1080	1470	1920	2430	3000
Horse power boiler fed	30	48	67	94	122	155	192
Price of engine and pump, &c. ..	£20 10	£25 5	£30	£34 15	£40 15	£46 15	£54

DOUBLE-ACTING PUMP, WITH TWO RAMS AND TWO CYLINDERS, Fig. 260.

Diameter of ram in inches ..	2	2½	3	3½	4	4½	5
Length of stroke „ ..	4	5	6	7	8	9	10
Number of strokes per minute ..	180	144	120	103	90	80	72
Gallons pumped per hour ..	950	1500	2160	2940	3840	4860	6000
Horse power boiler fed	60	96	134	188	244	310	384
Price	£40 15	£48	£55 5	£62 10	£72	£81 15	£93 15

Diameter of ram in inches ..	6	7	8	9	10	12	15
Length of stroke „ ..	12	14	16	18	20	24	30
Number of strokes per minute ..	60	51	45	40	36	30	24
Gallons pumped per hour ..	8640	11592	15360	19440	24000	34560	54000
Horse power boiler fed	552	741	982	1240	1536	2211	3456
Price	£120	£150	£186	£240	£306	£384	

The diameter of the steam cylinder will depend upon the steam pressure available, and the height to which it is desired to raise the water. Packing for shipment 3 per cent.

APPLEBY'S DIRECT-ACTING STEAM PUMP, Fig. 261. This compact, cheap, and durable form of direct-acting steam pump is so simple that it rarely gets deranged, and does not require the attention of a skilled driver. The working parts are either of hard gun metal or hardened steel. The cylinder is of hard grey cast iron accurately bored and fitted with a metallic piston with rings and springs. The admission of steam to the cylinder is regulated by an ordinary D valve driven by a return crank as shown. The crosshead is of wrought iron guided on both sides, and is cottered to the piston rod; there are double connecting-rods and a heavy disc fly-wheel, the whole being mounted on a suitable cast-iron base-plate provided with holes and bosses for foundation bolts for fixing the engine to brick work or timber as may be desired. These pumps are used for feeding boilers, as fire engines, for supplying tanks, or for lifting and forcing hot liquors. The pump is double acting, its piston being fitted with gun-metal rings and springs. Every pump is fully tested in steam before leaving the works.

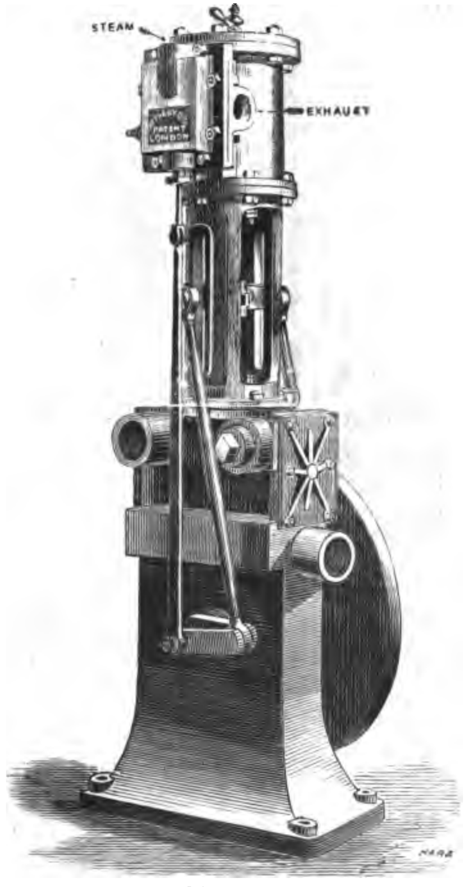

Fig. 261.

These pumps are very economical as regards consumption of steam, and being carefully designed and finished they are well adapted for permanent use, such as filling railway station and other storage tanks, one arrangement of which is illustrated by Fig. 262.

The number of gallons is calculated for 80 stroke of the pump per minute, this is a good average working speed, but it may be safely increased. A suitable air vessel £2 to £5 each.

For prices of flexible hose, unions, nozzle, &c., for fire engines, see pp. 124, 126, 142–151.

For prices of wrought-iron tubing see pp. 153 & 154.

Packing for shipment costs 4 per cent.

For smaller sizes of boiler feeders see pages 22 to 25.

PRICES OF DIRECT-ACTING PUMPS, Fig. 261.

Size number	5	6	7	8	9
Diameter of pump in inches	2¾	3	3¼	3½	4
Gallons delivered per hour	865	1050	1460	1700	3350
Approximate horse power of boilers which pump will feed	58	70	100	115	225
Diameter of steam supply pipe in inches	1¼	1¼	1¼	1¼	1¼
" " exhaust " "	1¼	1¼	1½	1¼	1¾
" suction pipe in inches	2	2	2	2	3
" delivery " "	2	2	2	2	2
Price complete, as shown	£35	£37	£40	£43	£60

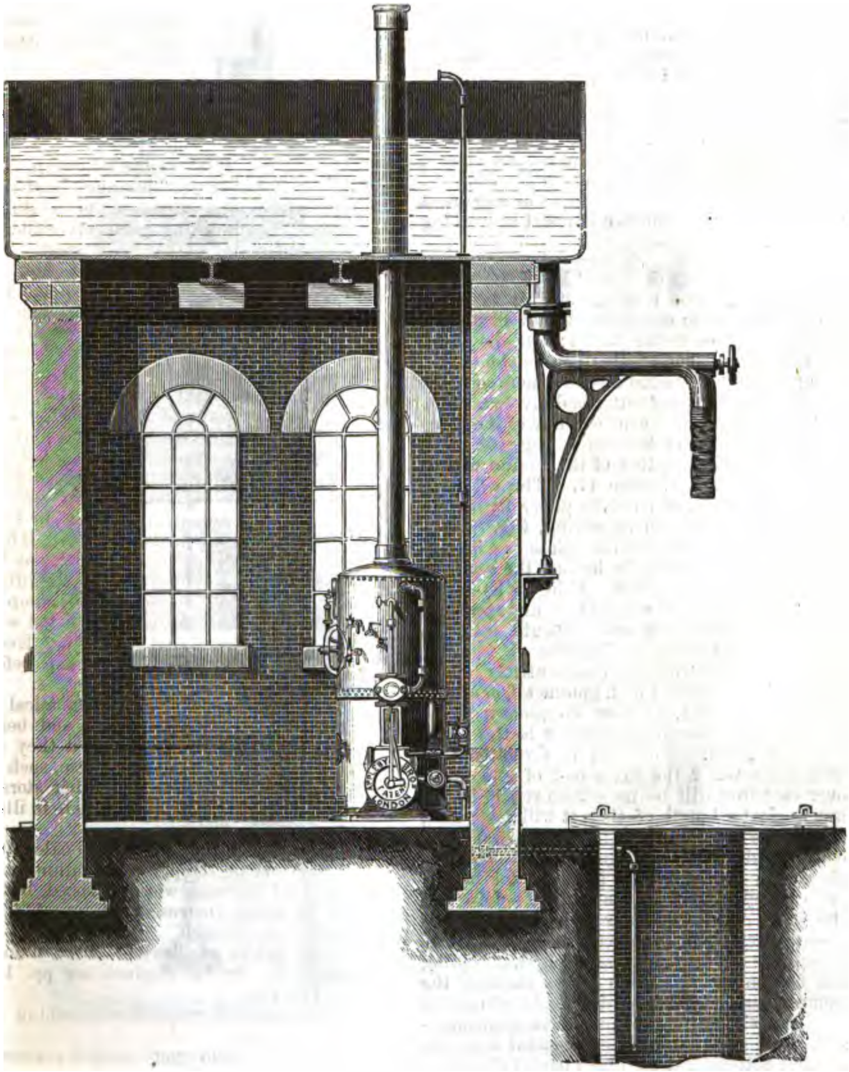

Fig. 262.

PUMPING ENGINE, TANK AND WATER CRANE, Fig. 262. Suitable for railway stations, factories, or country houses, in the latter case the water-crane being evidently not required. A vertical boiler of the type referred to, Section 1, pages 61 to 63, supplies steam to a direct-acting vertical pumping engine (see Fig. 261, page 14), or to a horizontal pumping engine (see Figs. 265 to 267). The tank forms the roof of the engine-house; the heat from the boiler and engine, with a chimney passing through a tube in the tank as shown, is sufficient in England to keep the water from freezing in cold weather. The water crane is carried by a cast-iron bracket fitted with a gun-metal toe step, and a gun-metal bushed gland at the top, leather hose, stop valve, &c. The cost of such machinery necessarily varies, with the proportions required. But a pump to draw from a well not exceeding 20 feet deep, and force 1,700 gallons per hour, cast-iron tank, 12.0 × 10.0 × 4.0, with boiler and water crane of 6 feet radius as shown, costs £195. No foundations are required beyond the ordinary wall and floor; this arrangement is low in first cost and economical in working expenses.

VERTICAL ENGINE, BOILER, AND WELL PUMPS, Fig. 263. Engines of this type are frequently used in connection with well pumps, either double or treble barrel; but the latter are to be recommended, the power of the engine being more equally absorbed as a more constant and regular stream of water is delivered. The boiler is vertical, and can be of any of the three forms referred to at Section 1, pages 61 to 63. The price and description of the engine will be found at Section 1, page 11. The cylinder, valves, standards, and details generally remain the same as shown in engraving, Fig. 8, Section 1, page 11; but the base-plate is enlarged sufficiently to carry the boiler and the bearings for the pump crank shaft. A heavy fly-wheel is fitted on the engine crank shaft, and spur gear of suitable proportion and strength connects the engine and pump crank shafts.

The pump barrels are made entirely in cast iron, cast iron bushed with gun metal, or of gun metal throughout, as may be preferred, the cost naturally varying according to the metal selected; but it should not be forgotten that with some water, the extra cost of gun metal over cast iron will be more than repaid by the much greater length of time it will last; also, that if the pumps should remain unused for a considerable time, less trouble will be experienced in starting again if gun-metal barrels are employed; but if the water is pure and the work constant, cast-iron barrels are frequently employed with excellent results. The pump rods are made of wrought iron, excepting the bottom length, which works through the pump gland, this is usually made of copper. The pump has wrought-iron forked connecting-rods fitted with adjustable gun-metal bearings, top and bottom, and the upper part of the pump

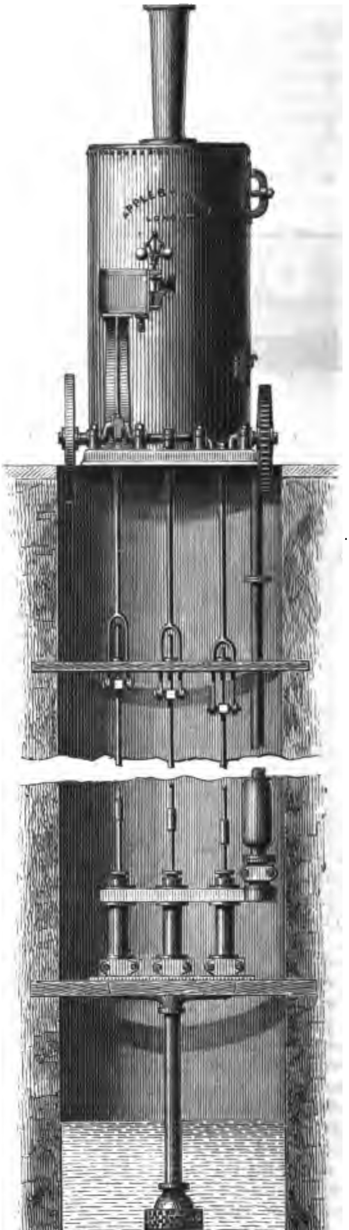

Fig. 263.

rod works in guides bushed with gun-metal, and carried by girders fixed in the sides of the well. A wind bore and (usually) a foot valve is provided on the suction pipe, and an air vessel on the delivery pipe or rising main.

Pumps arranged on this system are suitable for almost any depth of well; and as the depth of well and quantity of water to be raised will vary in each case, a table of cost cannot be made which should cover every example. It may, however, serve as a guide to know that a 4 horse-power engine and boiler complete, with treble barrel-pumps, 6 inches diameter, and 18 inches stroke, of cast iron, lined with gun metal, and capable of delivering 160 gallons per minute (9,600 per hour), from a well of 100 feet deep, costs £275, including suction and delivery pipes, wind-bore, air vessel, &c., complete and ready for fixing.

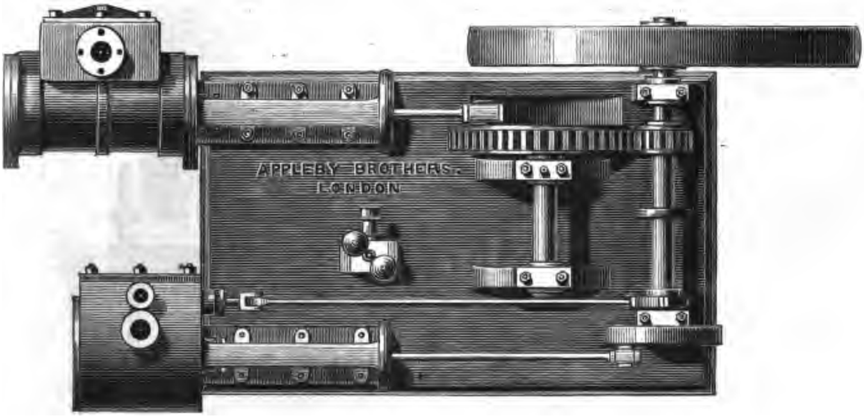

Fig. 264.

HORIZONTAL GEARED PUMPING ENGINE, Fig. 264, is suitable for drawing from any depth up to 25 feet, and forcing to any reasonable height; also for drainage and irrigation purposes, supplying railway tanks, factories, small towns, or for contractors' work. As will be seen from the engraving, the arrangement consists of a horizontal double-acting lift and force pump driven by a horizontal engine through a spur wheel and pinion, the steam piston may therefore travel at a sufficient speed to secure economy in consumption of steam, whilst the pump runs at the moderate speed necessary for efficient working. In direct-acting pumping engines, unless carefully designed, either the steam piston moves too slowly to obtain an economical consumption of fuel in proportion to the work done, or the pump piston runs so fast that the pump cannot be entirely filled at each stroke. The steam cylinders are cast of the best grey metal in one with the guide bars, both the cylinder and guides being accurately bored and fitted; the piston is metallic, and fitted with rings, springs, &c. The piston rod is steel, and is cottered into the cast-iron cross-head. If necessary, a boiler feed pump can be fitted on the top of the cylinder driven from the cross-head. The connecting-rod is made of best scrap iron, and fitted with adjustable gun-metal bearings at each end. The crank shaft is of scrap iron, with crank plate, and is carried by two plummer blocks, fitted with adjustable gun-metal bearings. A heavy fly-wheel is keyed to the crank shaft. The spur gearing is of the proper strength and proportions, the teeth being of the most approved shape for working noiselessly and economically. The pump is driven from the large spur wheel, turned bright; into which is rivetted a wrought-iron crank pin. There is a wrought-iron turned connecting-rod fitted with gun-metal adjustable bearings at the crank pin end, and bushed with gun metal at the cross-head end. The cross-head is of cast iron cottered to the pump rod, the guides are bored and bolted to the pump cylinder and the bed-plate, and form a guide to the pump like that on the steam cylinder. The pump is double acting and is made of cast iron bushed with gun metal, or entirely of gun metal. The valves can be of almost any sort, such as metal to metal, or an india-rubber disc with gun-metal gratings and guard plate. A suitable air vessel is provided on the delivery. The whole is mounted on a strong cast-iron bed-plate provided with the necessary facings for the various parts to be bolted to, and with holes for foundation bolts.

Pumping engines of this type make excellent fixed fire engines. The following list gives the prices of these engines complete, with cast-iron pumps, cast-iron air vessel and bed-plate, but exclusive of foundation bolts or steam connections.

The arrangement admits of other combinations being readily made to suit any quantity or head of water.

PRICES OF HORIZONTAL GEARED PUMPING ENGINES, Fig. 264.

Nominal horse power	3	4	5½	3	4	5½	3	4
Diameter of steam piston in inches	5½	6½	7½	5½	6½	7½	5½	6½
Stroke of " " " ..	9	10	10	9	10	10	9	10
Diameter of pump " " ..	4	4	4	5	5	5	6	6
Stroke of " " " ..	12	12	12	12	12	12	15	15
No. of gallons pumped per hour ..	2600	2600	2600	4050	4050	4050	4900	4900
Height to which water is forced in ft.	230	300	345	150	200	225	120	160
Price complete	£60	£70	£80	£68	£78	£88	£80	£90

Nominal horse power	5½	3	4	5½	7	8	10	3
Diameter of steam piston in inches	7½	5½	6½	7½	8½	9	10	5½
Stroke of " " " ..	10	9	10	10	14	14	14	9
Diameter of pump " " ..	6	8	8	8	8	8	8	10
Stroke of " " " ..	15	15	15	15	15	15	15	18
No. of gallons pumped per hour ..	4900	8500	8500	8500	8500	8500	8500	16000
Height to which water is forced in ft.	180	70	95	105	165	190	240	35
Price complete	£100	£105	£115	£125	£135	£145	£160	£125

Nominal horse power	4	5½	7	8	10	7	8	10
Diameter of steam piston in inches	6½	7½	8½	9	10	8½	9	10
Stroke of " " " ..	10	10	14	14	14	14	14	14
Diameter of pump " " ..	10	10	10	10	10	12	12	12
Stroke of " " " ..	18	18	18	18	18	18	18	18
No. of gallons pumped per hour ..	16000	16000	16000	16000	16000	23000	23000	23000
Height to which water is forced in ft.	45	55	85	100	125	60	70	90
Price complete	£135	£145	£155	£165	£180	£175	£185	£200

If bushed with gun metal, 6 per cent. extra.
Packing for shipment, about 4 per cent.
For boilers suitable for these pumps see Section 1, pages 54 to 64.

HORIZONTAL ENGINE AND DEEP WELL PUMP, Fig. 265, shows a plan and elevation of an arrangement for pumping from deep wells by steam power. A horizontal engine is connected by spur gear to the three-throw crank of a treble-barrel well pump; this admits the steam piston being maintained at a sufficiently high speed for economy of fuel, whilst the speed of the pumps is slow enough for efficient working. The horizontal engine is complete and self-contained, and is exactly similar to those referred to in Section 1, p. 8; if not required for pumping, the engine may be utilized for driving any machinery, the power being taken from the pulley shown in the plan, by a leather or india-rubber belt. In the engraving ordinary slow speed governors are shown, but these can be replaced by Appleby's high speed governors, if desired; or, if the engine is to be used for pumping against a constant head, the governors may be altogether omitted without materially impairing the efficiency. A heavy fly-wheel is keyed on to the engine crank shaft, and the outer crank shaft bearing is bolted to the pump plate. A cast-iron plate, or in large sizes four girders, span the top of the well and carry the bearings for the pump crank shaft. This crank shaft is of best wrought iron, the cranks being bent so that the grain and the full strength of the iron is preserved. A bearing is provided between each pair of cranks, fitted with loose cap, bolts and nuts, and adjustable gun-metal bearings. The pump connecting-rods are wrought iron, forked at the lower end to span the guides, and fitted with adjustable gun-metal bearings. The end of the pump rod works in a gun-metal bushed guide, the rods being further guided where necessary by brackets fixed to timbers or other bearers bricked into the walls. The pumps are of the ordinary kind, the various sizes and prices of which will be found at pp. 101 and 102. The three pumps all draw their water through one large pipe fitted with a windbore or strainer at the bottom, and deliver into one cast-iron rising main furnished with a retaining valve and air vessel. Doors are provided to render it easy to examine both the pump valves and retaining valve. Although it is not always necessary, it is generally better to have gun-metal pump barrels, or for the larger sizes, cast-iron barrels bushed with gun metal.

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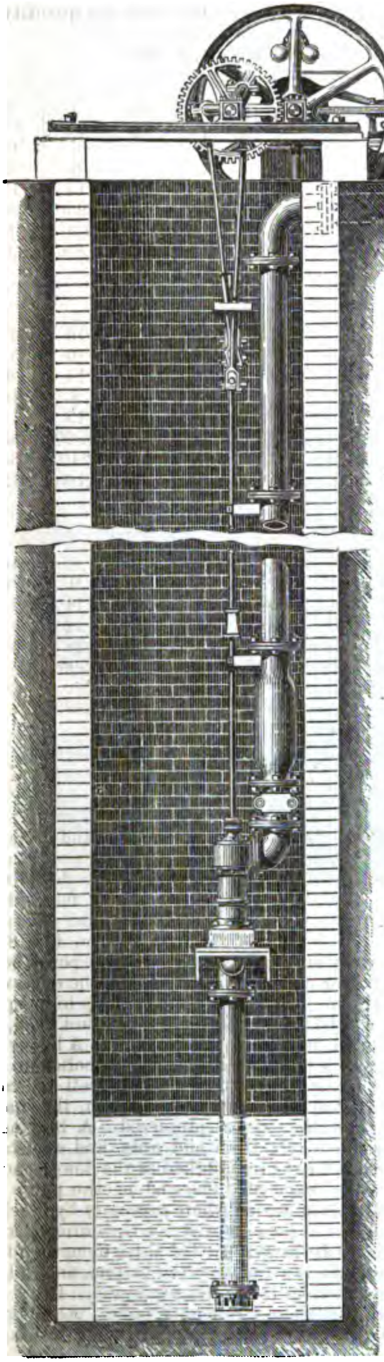
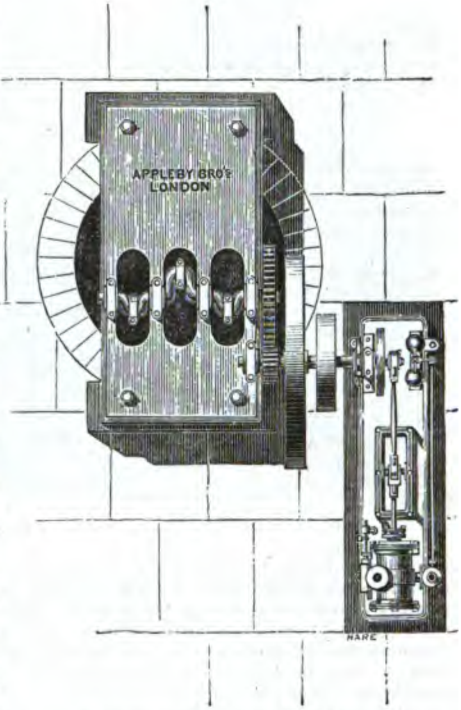


ELEVATION AND PLAN OF DEEP-WELL PUMPS WITH ENGINE, DRIVING GEAR, AND WELL PLATE.



The conditions under which machinery of this description vary so much render it impossible to estimate the cost without having in every case full details of the depth of the well, the quantity of water required in a given number of hours, and the maximum height above the surface to which the water has to be raised or forced; but the prices of the various parts will be found in their respective sections, which will enable anyone to make an approximate estimate of the cost of such work.

Fig. 265.

DIRECT-ACTING STEAM PUMPS. The advantages possessed by direct-acting steam pumps of the construction illustrated by Figs. 266 to 268 are almost universally acknowledged; and there can be no better argument in their favour than the fact that thousands have been in constant work for many years and they are still being sold extensively. They occupy a small space, cost but little, are easily and quickly fixed, requiring no special foundations, and can be applied to any purpose for which steam pumping machinery is required, whether for hot or cold liquids, chemicals or semi-fluids. The most improved type have few working parts, there being no fly-wheel, governors, crank, crank shaft and bearings, connecting-rod, eccentrics or eccentric rods, and the wear and tear is consequently reduced as compared with engines of the ordinary type. They are especially applicable for intermittent or temporary use in draining quarries or mines, as they can be fixed in the workings and will force water to almost any height, some being already at work against a head of a thousand feet and upwards. The total cost of a direct-acting steam pump for mining purposes would scarcely exceed the outlay necessary for the foundations of an ordinary Cornish beam pumping engine; but on the other hand, they are less economical in consumption of steam than those engines which will work expansively. They are suitable for boiler feeders and for employment in factories, chemical-manure and soap works, &c., and are largely employed by brewers, and to supply water to public baths and wash-houses. They can be arranged especially for use as fire-engines or for contractors' work, raising sunken vessels, &c., where large quantities of water are to be delivered to a comparatively small height. Special valves are fitted in pumps for pumping sewage, tar, alcohol, tan liquor, &c. Lists are given of the sizes usually made, but any other combination can be arranged, and the only data required is the quantity of water to be pumped in a given time, the height to which it is to be forced, and the available steam pressure, if the pump is to be used in connection with an existing boiler. Direct-acting steam cylinders are sometimes combined with air pumps for use as blowing engines, for blast furnaces, ventilating mines, or in connection with pneumatic dispatch tubes. Direct-acting pumps are also made to be driven by compressed air.

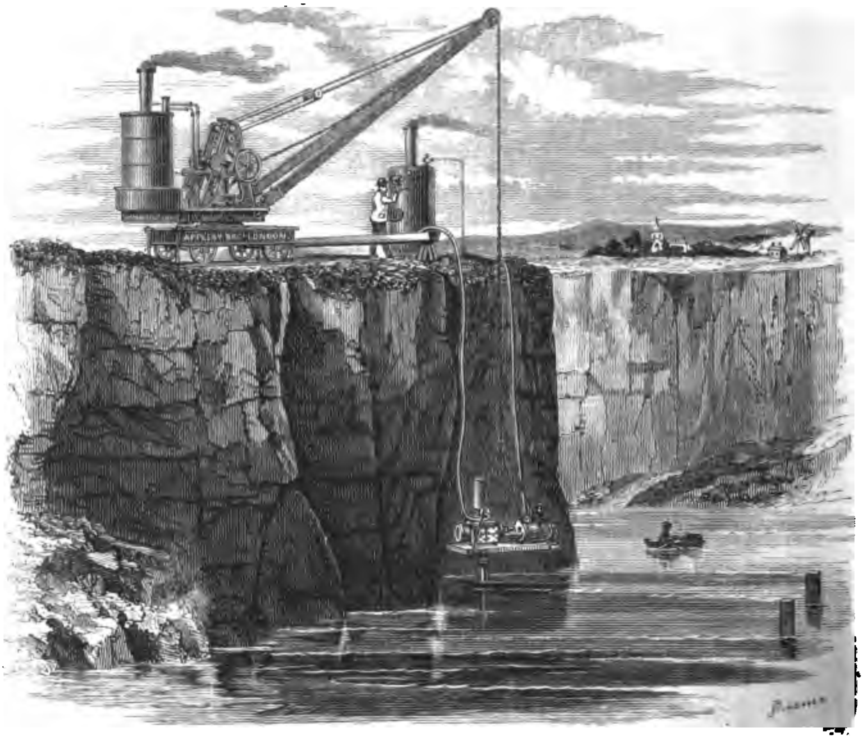


Fig. 266.

CAMERON'S STEAM PUMP, Fig. 267. is fitted with a Holman's patent steam condenser, and at pp. 17 to 20, Section 1, this and several other condensers are described which may be used in connection with steam pumps. Condensers similar to that shown in the engraving are made to suit any kind and size of steam pump, and are said to effect a saving of from 20 to 25 per cent. of fuel, whilst they also get rid of the exhaust steam which is often a great nuisance in mining and tunnelling operations. The condenser forms a part of the suction pipe, and maintains a vacuum of about 11 lbs. per square inch; this pressure acting, as it does, on the whole area of the piston, naturally largely increases the power, and consequently the efficiency and economy of the pumping engine. If the pump is intended for feeding boilers, a condenser of this or a similar sort should be attached to it, as the heat of the exhaust steam is absorbed by the feed water, and passes with it into the boiler, producing a marked economy in the consumption of fuel. These condensers being self-acting require no adjustment or special attention of the engine-driver.

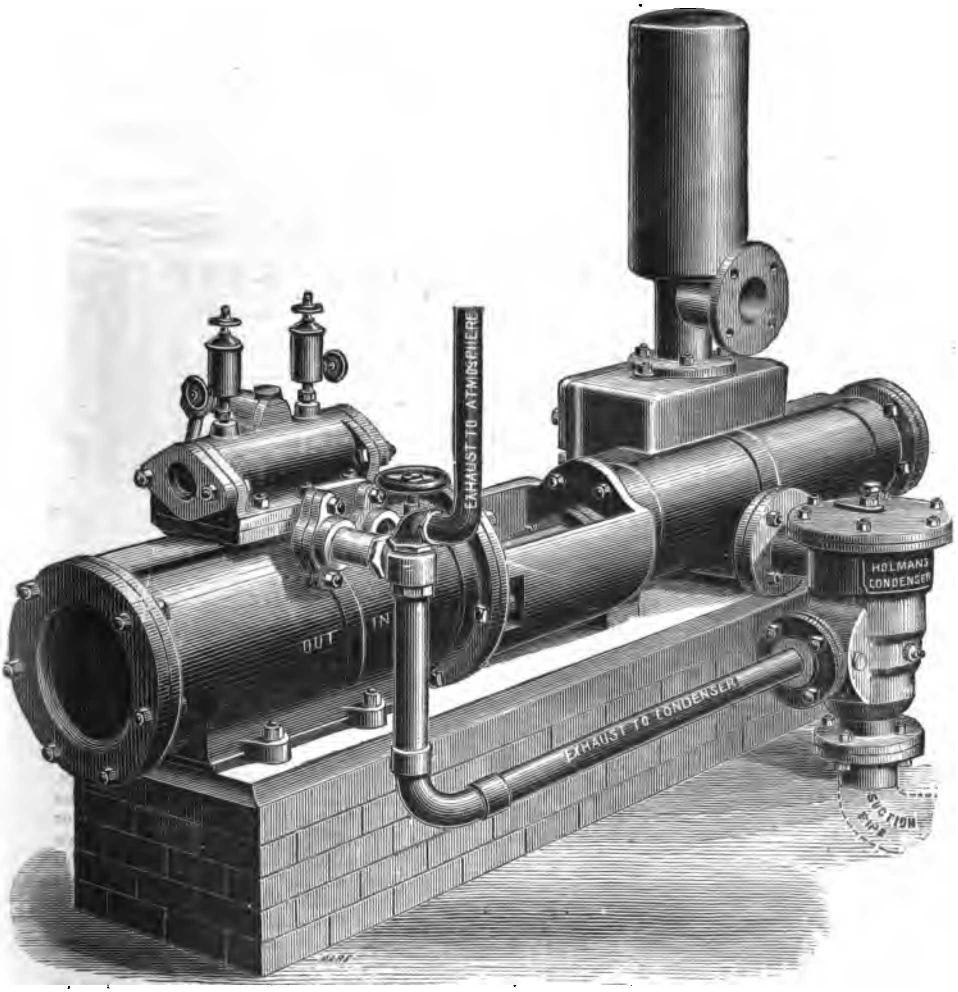


Fig. 267.

SIZES AND PRICES OF DIRECT-ACTING STEAM PUMPS, Figs. 266 and 267.

Steam Cylinder . . . . In.	3	3	4	4	4	5	5	5	6	6	6	6	7	7	7	7	7	8
Water Cylinder . . . . In.	1½	3	2	3	4	3	4	5	3	4	5	6	3	4	5	6	7	4
Stroke . . . . In.	9	9	9	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
Gallons per Hour, Approximate	450	1830	815	1830	3250	1830	3250	5070	1830	3250	5070	7330	1830	3250	5070	7330	9750	3250
Suction and Delivery . . In.	1	2	1½	2	3	2	3	3½	2	3	3½	4	2	3	3½	4	5	3
Steam Inlet . . . . . In.	½	½	¾	¾	¾	¾	¾	¾	¾	¾	¾	¾	1	1	1	1	1	1¼
„ Exhaust . . . . . In.	¾	¾	1	1	1	1	1	1	1	1	1	1	1¼	1¼	1¼	1¼	1¼	1½
Weight, Approximate . .Cwt.	1.1.0	2.3.7	2.1.14	3.2.0	3.3.0	3.3.0	4.2.0	6.0.0	4.1.22	5.1.14	7.0.14	9.2.10	4.3.0	5.2.8	7.3.0	8.3.0	12.0.7	6.3.20
Total Length and Width . In.	36×6	44×13	42×8	48×13	48×14	48×13	48×15	48×15	48×13	48×15	48×16	51×17	52×15	52×16	54×18	54×18	55×20	51×17
PRICE	**£16**	**£18**	**£18**	**£20**	**£25**	**£22 10**	**£27 10**	**£32 10**	**£25**	**£30**	**£35**	**£40**	**£30**	**£35**	**£40**	**£45**	**£50**	**£40**

SIZES AND PRICES—*continued.*

Steam Cylinder . . . . In.	8	8	8	8	8	9	9	9	9	9	10	10	10	10	10	10	12	12
Water Cylinder . . . . In.	5	6	6	7	8	5	6	7	8	9	5	6	7	8	9	10	6	7
Stroke . . . . In.	12	12	18	12	18	12	12	12	18	24	12	12	12	18	24	24	18	18
Gallons per Hour, Approximate	5070	7330	7330	9750	13,000	5070	7330	9750	13,000	16,519	5070	7330	9750	13,000	16,519	20,000	7330	9750
Suction and Delivery . . In.	3½	4	4	5	6	3½	4	5	6	7	3½	4	5	6	7	8	4	5
Steam Inlet . . . . . In.	1¼	1¼	1¼	1¼	1¼	1¼	1¼	1¼	1¼	1¼	1¼	1¼	1¼	1¼	1¼	1¼	2¼	2¼
„ Exhaust . . . . . In.	1½	1½	1½	1½	1½	1¾	1¾	1¾	1¾	1¾	1¾	1¾	1¾	1¾	1¾	1¾	2½	2½
Weight, Approximate . .Cwt.	9.0.0	11.0.0	11.2.0	9.2.0	13.0.0	9.1.0	9.1.14	9.2.0	13.2.0	24.0.0	9.3.0	9.3.22	10.0.0	18.0.0	26.0.0	27.2.0	18.2.0	9.0.0
Total Length and Width . In.	54×18	54×19	60×20	56×21	66×22	58×20	58×21	58×21	72×25	90×27	58×21	58×21	58×21	72×25	92×27	92×27	74×20	74×23
PRICE	**£45**	**£50**	**£60**	**£55**	**£65**	**£50**	**£55**	**£60**	**£70**	**£85**	**£55**	**£60**	**£65**	**£75**	**£90**	**£100**	**£75**	**£80**

SIZES AND PRICES—*continued.*

Steam Cylinder . . . . In.	12	12	12	12	14	14	14	14	14	14	16	16	16	16	18	18	18	21
Water Cylinder . . . . In.	8	9	10	12	7	8	9	10	12	14	8	10	12	14	10	12	14	12
Stroke . . . . In.	18	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	36
Gallons per Hour, Approximate	13,000	16,519	20,000	30,000	9750	13,000	16,519	20,000	30,000	40,000	13,000	20,000	30,000	40,000	20,000	30,000	40,000	30,000
Suction and Delivery . . In.	6	7	8	9	5	6	7	8	9	10	6	8	9	10	8	9	10	9
Steam Inlet . . . . . In.	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	3	3	3	3½
„ Exhaust . . . . In.	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	3	3	3	3	3½	3½	3½	4
Weight, Approximate . .Cwt.	19.2.10	27.0.0	30.0.0	36.0.0	21.1.0	22.2.14	24.0.0	32.0.0	38.0.0	...	...	...	...	...	...	...	...	...
Total Length and Width . In.	74×25	94×27	94×27	96×30	98×27	100×28	100×28	100×30	100×30	...	...	...	...	...	...	...	...	...
PRICE	£85	£110	£120	£140	£110	£120	£130	£140	£160	£180	£140	£160	£180	£200	£200	£220	£240	£285

SIZES AND PRICES OF STEAM PUMP WITH BOILER, &c., COMPLETE ON ONE BED-PLATE.

Diameter of Steam Cylinder . . . In.	3	4	4	4	6	6	6	6	7	7	7	8	8	10	12
Diameter of Water Cylinder . . . In.	1½	2	3	4	3	4	5	6	5	6	7	6	8	8	9
Length of Stroke . . . . In.	9	9	12	12	12	12	12	12	12	12	12	12	18	18	18
Gallons per Hour, Approximate . . .	450	815	1830	3250	1830	3250	5070	7330	5070	7330	9750	7330	13,000	13,000	16,519
Diameter of Suction and Delivery . In.	1	1½	2	3	2	3	3½	4	3½	4	5	4	6	6	7
PRICE {Complete with Boiler and fittings, but exclusive of Boiler Feeder . . . .}	£56	£60	£65	£70	£75	£85	£100	£105	£105	£110	£115	£125	£145	£175	£195

Injector boiler feeder, £7 extra. Or steam pump for feeding boiler, extra, according to size. If brass lined, or solid brass or gun-metal water cylinders, with copper air vessels, extra, according to size. Any combinations can be made between the steam and water cylinders to suit pressure of steam and height of lift, thus—8 in. steam and 4 in. water, or 12 in. steam and 6 in. water, and so on. The length of stroke can also be increased at a proportionate extra charge.

The sizes of steam pipes given in the above list are only those for ordinary distances between pump and boiler. Where long lengths of pipe are necessary, the sizes must be increased. The above duties are calculated at the usual piston speed of 120 feet per minute.

"UNIVERSAL" STEAM PUMP, Fig. 268, illustrates another direct-acting steam pump which is applicable to the same purposes as Figs. 266 and 267. The mechanical arrangements are very simple, all the steam gear being in the piston, so that the only external part which moves is a few inches of piston rod. The pump valves consist of gutta-percha balls. It can be fitted with the condensers if desired.

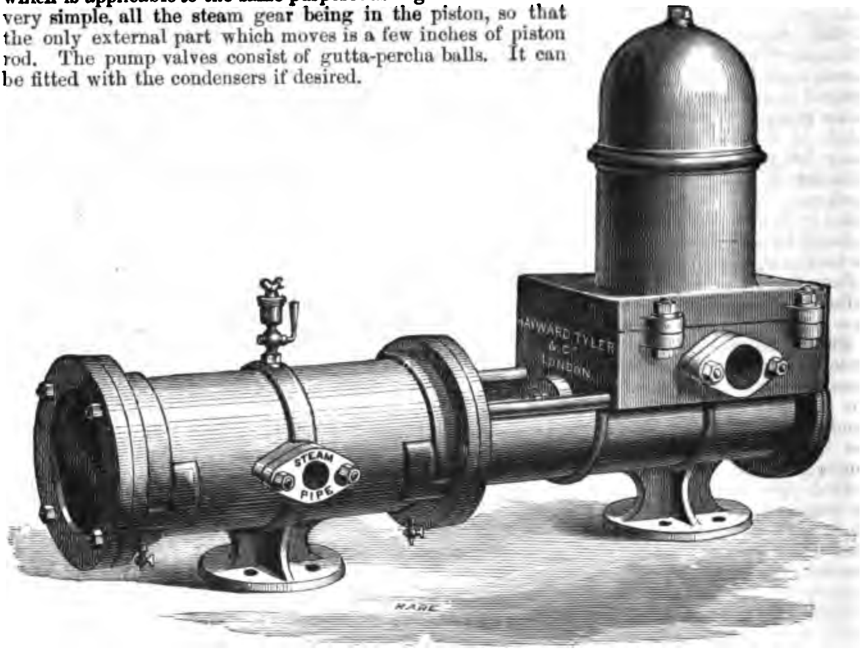


Fig. 268.

Prices of Universal Steam Pump, Fig. 268.

Steam cylinder, in inches	4	4	4	5	5	5	6	6	6	6	7
Water „ „	2	3	4	3	4	5	3	4	5	6	4
Suction pipe „	1	2	2½	2	2½	3	2	2½	3	4	2½
Delivery „ „	1	1½	2	1½	2	2½	1½	2	2½	3	2
Steam „ „	¾	¾	¾	¾	¾	¾	1	1	1	1	1
Exhaust „ „	1	1	1	1	1	1	1¼	1¼	1¼	1¼	1¼
Galls. per hour (approx.)	750	1750	3000	2000	3500	5500	2000	3500	5500	7900	3500
No. of strokes per min.	100	100	100	85	85	85	85	85	85	85	85
Total length in inches ..	36	36	42	44	46	48	44	46	48	52	46
„ width „	10	12	13	12	13	15	12	13	15	17	13
Approx. weight, in lbs. ..	188	231	306	304	384	522	392	448	560	700	460
Price	£18	£22	£25 10	£25	£28 10	£32 10	£27	£31 10	£35	£42 10	£35

Steam cylinder, in inches	7	7	7	9	9	9	12	12	12	12	12
Water „ „	5	6	7	5	6	7	6	7	8	10	12
Suction pipe „	3	4	5	4	4	5	5	5	6	9	9
Delivery „ „	2½	3	4	3	3	4	4	4	5	8	9
Steam „ „	1	1	1	1½	1½	1½	2	2	2	2	2
Exhaust „ „	1¼	1¼	1¼	2	2	2	2½	2½	2½	2½	2½
Galls. per hour (approx.)	5500	7900	10800	5500	7900	10800	7700	10500	13700	21500	31000
No. of strokes per min.	85	85	85	70	70	70	55	55	55	55	55
Total length in inches ..	48	52	64	58	58	66	66	74	82	87	87
„ width „	15	17	26	17	17	26	26	26	30	37	37
Approx. weight in lbs. ..	556	738	1120	984	938	1316	1764	1240	2690	3640	4032
Price	£40	45	£58	£52	£55	£67	£80	£82	£102	£136	£155

Packing for shipment 4 per cent.

APPLEBY'S PATENT DONKEY PUMPING ENGINE for feeding boilers, &c., Fig. 269. The merits of these pumps have long been established. In 1867 the Commission of the Paris Exhibition selected them for use in the boiler house of the British Section, and the Jury awarded the "Médaille d'honneur" to the makers. Since then many minor improvements have been introduced, but without alteration to the general design and proportions; the result is a very perfect steam pump. The valves can be easily examined, and the whole of the mechanism is so simple and well arranged, there being no tappets or other parts requiring delicate adjustment, that they may be entrusted to an unskilled workman. The working parts and valves are of hard gun metal or hardened cast steel. The pump is fixed vertically, and may be employed for feeding boilers, supplying tanks, or for forcing hot liquors, &c. So many of the accidents to steam boilers are traceable to a temporary derangement of the ordinary feed apparatus, that it is most important there should be a separate means of feeding every boiler independently of the engine, and in many countries (though not in Great Britain) this is made compulsory. These pumps form an excellent auxiliary to the feed pump on the engine; they can be used for feeding the boiler when the engine is standing, which is frequently a great convenience, and the cost is so small as scarcely to be worth consideration in comparison with the advantages and additional safety derived from their use. An arrangement for working the pumps by hand is supplied at a small extra cost; this is a convenient adjunct, as by means of it the boiler can be filled when steam is not up, or can be tested by hydraulic pressure. If every steam boiler were tested by hydraulic pressure to about one and a half times the working pressure, at fixed periods about twice a year, any defective parts would most probably be discovered, and many accidents disastrous both to life and property might thus be averted. As some chemicals are deteriorated by contact with iron and others by contact with brass, these pumps are made entirely of either metal required, special quotations for which will be necessary. The pumps referred to in the subjoined list are single acting, and are recommended as being simple and efficient. The various sizes in the subjoined list are kept in stock, and can therefore be obtained at a very short notice. Each pump is distinctly marked with its size and number, and being made to gauges, duplicate parts can be had when desired if the size and number are mentioned. An air vessel may be fixed on the suction or delivery pipe, or on both, at a small increase of cost; and the arrangement admits of the suction pipe and valve being on either the right or left hand of the pump, as may be most convenient.

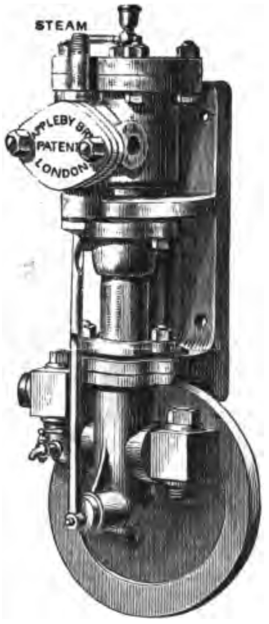


Fig. 269.

The quantities given in the following list are for single-acting pumps, worked at a hundred strokes per minute It is however advisable to have pumps larger than is theoretically required, and to run them at low speed, although being direct acting there is no risk in working them at a high speed.

PRICES OF DONKEY PUMPING ENGINES, Fig. 269.

Size number	0	1	2	3	4
Diameter of ram in inches	1⅛	1½	2	2¼	2½
Gallons per hour	60	100	185	310	400
Horse power of boiler fed	4	7	12	20	26
Diameter of steam pipe in inches	⅜	⅜	½	¾	¾
„ exhaust „ „	½	½	½	¾	¾
„ suction and delivery pipes.. ..	¾	¾	1	1¼	1¼
Price	£8	£9	£10 5	£13	£14
Hand gear extra	10/-	10/-	12/6	15/-	15/-
Packing in case	3/-	4/-	5/-	6/-	7/-

For prices of wrought-iron piping and connections suitable for these pumps, see pp. 153, 154.

For prices and particulars of larger pumps suitable for similar work, see Figs. 260 and 261, pp. 13 and 14.

BEHREN'S ROTARY PUMP AND ENGINE, Fig. 270. These engines and pumps have been for some years extensively used in the industrial establishments of America and the Continent of Europe, as well as by the Governments of the United States of America, France, Russia, &c. Prizes have been awarded at the American Institute, 1867; Paris Exhibition, 1867; and Havre Exhibition, 1868; and the working results have indicated many advantages. There are no valves and only two working parts, from which it may be inferred that the machines are not liable to derangement, and are very durable; whilst in regularity of motion they must necessarily be superior to any pump having a reciprocating action.

Behren's pumps were subjected to a series of exhaustive competitive tests and investigations, instituted, in the first instance, by the Government of the United States of America; subsequently, by the Imperial Governments of France, Russia, &c.; and, lastly, by the Author's firm prior to undertaking the manufacture for Great Britain. The results obtained were so satisfactory that these pumps were adopted by each of the Governments above named, and are now introduced in this country.

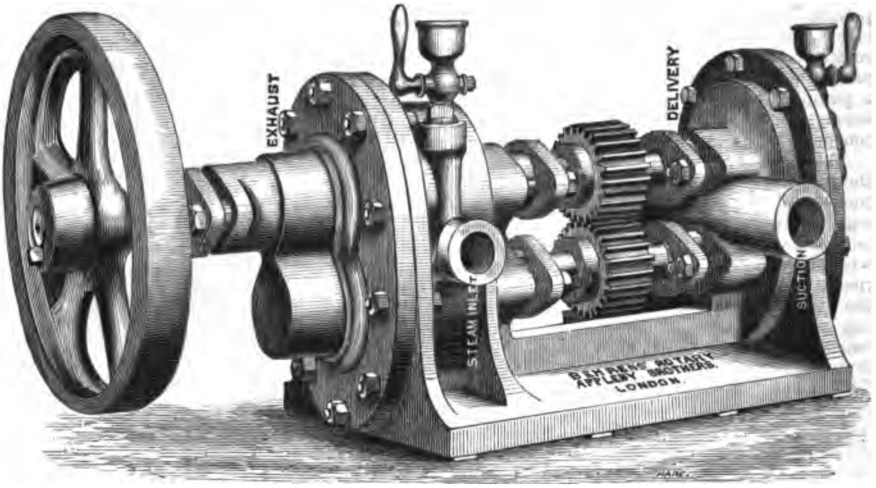


Fig. 270.

In Fig. 270 the engine and pump are combined: both are constructed on the same principle, and each is complete in itself, the only difference being that the relative piston areas of the engine and pump are varied according to the work to be done. Engines of this class can be made on the compound principle so as to use the steam expansively; but the cost of fuel is rarely so excessive as to render this necessary, the ordinary engines being sufficiently economical under all ordinary conditions.

The steam and water connections are of the ordinary kind, and, as will be seen from the engravings, are easy of access; the larger sizes are made with flanged connections, but the smaller sizes are usually fitted for screwed pipes.

The principle on which Behren's rotary pumping engine is constructed will be easily understood if reference is made to Fig. 271 which represents a section of the engine and pump, and clearly shows the internal arrangement. The pistons A A′ are attached to cast-steel shafts B B′ parallel with each other, and geared together with spur wheels as shown in Fig. 270; the teeth of these wheels are very accurately cut so as to work almost noiselessly. These shafts, therefore, rotate at equal speeds and in opposite directions. The segmental pistons A A′ are concentric with their respective shafts, and their outer (or larger) surfaces rotate within the cylinders C C′, whilst their inner (or smaller) surfaces rotate around the stationary bosses *b b′*. The axes of the shafts are spaced such a distance apart that the outer surface of the piston A fits into a recess in the fixed boss *b′*, whilst the outer surface of piston A′ fits into a recess in the fixed boss *b*, so that in their rotation about these bosses, steam, water, or whatever gas or liquid is acting, or being acted upon by the pistons, is prevented from passing between the pistons and bosses. This is the distinctive feature of the invention, and it ensures that economy in working which has not hitherto been obtained in the rotary engine or pump.

From the foregoing description it will be seen that by simplicity in the arrangement, and in the number of working parts, the chance of derangement is reduced to a minimum, and as there are no valves to get out of order, beer, thick wash, cold or hot molasses, oil, water, or other fluids are pumped with equal facility and certainty; therefore, these pumps are particularly adapted for dealing with thick (but not sandy or gritty) fluids.

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The bilge pumps on board the French ironclads; Solferino, Magenta, &c., also the large circulating pumps for the American Navy, and the liquor pumps supplied to Messrs. Truman, Hanbury, and Co., are on the compound (Woolf's) system before mentioned. This arrangement forms the subject of a separate patent, which includes a very efficient and inexpensive system of surface condensation. The application of these improvements to a pumping engine where a high average duty is required for fuel consumed, is a decided advantage.

A very neat arrangement of the portable rotary pumping engine consists of the pump and engine together, with the boiler and connections mounted on a strong wrought-iron carriage, which is carried on suitable wrought-iron wheels, the front pair being fitted with locking gear and shafts. This forms a handy machine for irrigation or drainage, or for contractors' use. The pumps are sometimes made entirely of brass, in which case the cost is of course considerably increased; in the arrangement shown in Fig. 270 the extra cost is 25 per cent. To decide the requisite size of these pumping engines it is necessary to know the number of gallons to be delivered per hour or minute, the height, and the available steam pressure, if it be intended to take steam from an existing boiler.

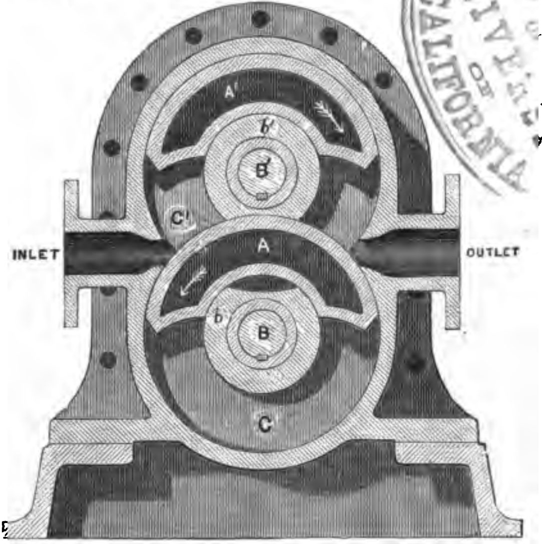

Fig. 271.

PRICES OF BEHREN'S ROTARY PUMPING ENGINES, Figs. 270 and 271.

Size number ..	1	2	3	4	5	6
Gallons per minute	8 to 15	20 to 40	40 to 80	80 to 150	150 to 250	180 to 300
„ hour ..	480 to 900	1200 to 2400	2400 to 4800	4800 to 9000	9000 to 15000	10800 to 18000
Will feed boilers H.P.	30	80	150	300	400	600
Diam. of water pipes	1″	1¼″	2″	3″	4″	..
Length of base ..	1′ 2″	1′ 8″	2′ 1″	2′ 3″	2′ 8″	..
Width of base ..	10″	1′ 3″	1′ 8″	2′	2′	..
Extreme height ..	11″	1′ 4″	1′ 9″	2′ 4″	2′ 9″	..
Price	£30 10	£36	£60	£78	£110	£160

Packing for export 3 to 5 per cent. extra.
If with gun-metal pumps add 25 per cent. to the prices in the above list.

BEHREN'S ROTARY POWER PUMP, DRIVEN BY STRAP, Fig. 272. Although the combined engine and pump shown in Fig. 270, and described in the preceding pages, is the arrangement most frequently adopted, where there is a motive power available the pump alone is used as shown in Fig. 272.

In the arrangement for large sizes the two shafts are placed on the same level, instead of one above the other as in Fig. 270; this saves height and adds to the stability of the whole. The pump is mounted on one end of a strong cast-iron base plate, the other end of which carries the outer bearings for the shafts; holes are provided in the base plate for holding down bolts.

The power is transmitted to the pump through a strap on the fly-wheel, which is accurately balanced, turned on the rim, and keyed to one of the shafts with a sunk steel key The bearings are of gun metal or patent white metal.

In fixing these pumps it is advisable to place them as near as practicable to the water to be pumped; they will, however, draw from a depth not exceeding about 24 feet, and will force to almost any height.

The prices given below are for cast-iron pumps and do not include straps, foundation bolts, or any piping. Add 25 to 30 per cent. if the pump is made in gun metal. For water engines on the same principle as these pumps, see p. 53, Section 1.

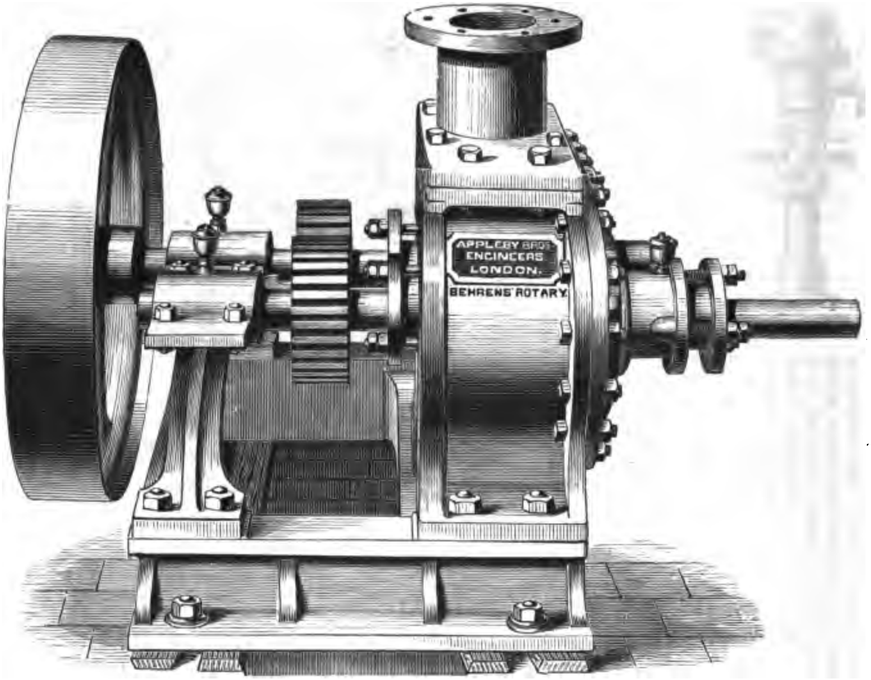

Fig. 272.

Prices of Behren's Rotary Pumps on Base Plate.

Size number	1	2	3	4	5	6
Gallons delivered per hour	900	2200	4400	8800	13·500	18·000
Price complete as shown	£23 5	£27	£44	£52	£81	£126

Packing for shipment about 3 to 5 per cent. For prices of suitable piping, see pp. 148 to 154.

INJECTORS FOR BOILER FEEDING, &c., Fig. 273. The injector is a very convenient, and compact form of feeder for boilers of all kinds, whether locomotive, marine, stationary, or portable; this is amply demonstrated by the thousands which are now in use all over the world. A jet of steam forces the feed water into the boiler, and as the injectors will feed a boiler working under even a higher pressure than that from which the jet is taken, the action seems at first sight rather paradoxical. If, however, we remember that the expenditure of steam is about fourteen times the volume of the water injected, and that the same quantity of steam employed in a donkey pump would have easily performed the same work, the result obtained from injectors ceases to be astonishing. The power in a jet of steam is expended in giving momentum to its particles, and it is clear that any apparatus which utilised this power without waste would produce as great an effect as a steam engine. It is essential for the working of injectors that the feed water supplied be not too hot to condense the jet of steam, and it has been found in practice that the temperature of the feed water should never exceed 135° Fahrenheit, and if it does, the injector will not work satisfactorily. The injector shown in Fig. 273 is an improved Giffard, with a self-contained foot valve, and self-contained means of regulating both the steam and water supply, and is, therefore, capable of working well at all pressures. Although injectors will draw their water from a considerable distance, it is advisable, if possible, to let the head of the feed water be slightly above the injector. The smaller sizes will draw from 2 to 5 feet, and the larger up to 12 feet, and in some cases injectors have been specially designed to draw 15 or 20 feet. Mr. Webb, the eminent chief of the locomotive department of the London and North-Western Railway, has designed and adopted an injector which does not have to draw. Injectors ought to have a continuous supply of dry steam regulated by a valve on the boiler or steam pipe; also a continuous supply of water which should not be hotter than 105° Fahrenheit for low pressures, or 135° for high pressures; there should also be a check or back pressure valve on the delivery pipe.

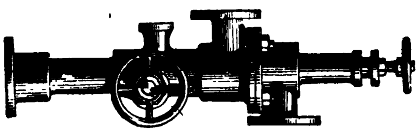

Fig. 273.

PRICES OF INJECTORS, Fig. 273.

Size of Injectors in Millimetres.	PRICE AT THE WORKS.				PIPES. Internal diam. in inches.	PRESSURE OF STEAM.													
	Brass.		Iron.			10lbs.	20lbs.	30lbs.	40lbs.	50lbs.	60lbs.	70lbs.	80lbs.	90lbs.	100lbs.	110lbs.	120lbs.	130lbs.	140lbs.
	£	s.	£	s.		DELIVERY IN GALLONS PER HOUR.													
2	4	0	3	10	½	25	35	43	50	56	61	66	71	75	80	83	87	91	93
3	5	0	4	5	½	56	80	97	112	126	138	150	160	170	178	187	196	203	211
4	6	0	5	0	1	100	142	173	201	225	246	266	285	301	317	333	348	362	376
5	7	0	5	15	1	157	222	272	313	351	385	416	445	471	496	522	545	566	587
6	9	0	6	15	1¼	226	320	392	452	506	555	598	640	678	715	750	783	816	846
7	11	0	7	15	1¼	307	4 5	533	616	688	755	815	871	923	973	1021	1067	1110	1152
8	13	0	9	0	1½	402	568	696	803	898	985	1062	1137	1206	1272	1335	1393	1450	1505
9	15	0	10	10	1¾	508	720	882	1017	1138	1247	1347	1440	1527	1610	1688	1763	1835	1905
10	17	0	12	0	2	628	888	1088	1256	1405	1540	1663	1777	1936	1987	2086	2177	2266	2352
11	19	0	14	0	2	760	1075	1317	1520	1700	1863	2012	2150	2281	2405	2522	2633	2742	2846
12	21	0	16	0	2¼	905	1280	1567	1810	2023	2217	2395	2560	2715	2861	3002	3136	3263	3387
13	23	0	18	0	2¼	1061	1501	1840	2123	2352	2602	2810	3005	3187	3358	3523	3680	3830	3975
14	26	0	20	0	2½	1231	1741	2133	2462	2753	3018	3261	3485	3696	3895	4087	4267	4441	4610
15	29	0	22	0	2½	1413	1998	2450	2827	3161	3465	3742	4000	4242	4471	4691	4900	5098	5292
16	32	0	24	0	2¾	1608	2275	2787	3217	3597	3942	4257	4551	4827	5087	5337	5575	5801	6022
17	35	0	26	0	2¾	1817	2567	3146	3631	4061	4450	4806	5138	5450	5743	6026	6291	6548	6798
18	38	0	28	0	2¾	2036	2878	3527	4071	4552	4090	5388	5760	6110	6438	6756	7055	7342	7633
19	41	0	30	0	2¾	2268	3207	3930	4536	5072	5560	6003	6418	6807	7175	7527	7861	8180	8492
20	45	0	33	0	3	2513	3553	4355	5026	5621	6160	6652	7110	7512	7950	8341	8710	9061	9410

Packing and delivery in London, Liverpool, or Hull, about 5 per cent.

PRICES OF INJECTORS, Fig. 274.

Size of Injector in Millimetres.	PRICES.								Internal diameter of pipe in inches.	NUMBER OF GALLONS DELIVERED PER HOUR AT SPECIFIED STEAM PRESSURES.														
	CLASS A.		CLASS B.		CLASS H.		CLASS I.																	
	Entirely of brass.	Cast-iron case, brass spindle and nozzle.	Entirely of brass.	Cast-iron case, brass spindle and nozzle.	Entirely of brass.	Cast-iron case, brass spindle and nozzle.	Entirely of brass.	Cast-iron case, brass spindle and nozzle.		lbs. 10	lbs. 20	lbs. 30	lbs. 40	lbs. 50	lbs. 60	lbs. 70	lbs. 80	lbs. 90	lbs. 100	lbs. 110	lbs. 120	lbs. 130	lbs. 140	lbs. 150
No.	£ s.	£ s.	£ s.	£ s.	£ s.	£ s.		£ s.																
2	3 15	3 10	2 15	2 12	3 15	3 10		3 0	½	20	30	40	50	50	60	60	70	70	80	80	80	90	90	90
3	4 0	3 15	3 0	2 17	4 10	4 0		3 10	½	50	70	90	110	120	140	150	160	170	180	180	190	200	210	210
4	5 15	4 10	3 18	3 5	5 15	5 0		4 0	1	100	140	170	200	220	240	260	280	300	310	330	340	360	370	390
5	6 5	4 15	4 10	3 10	6 15	6 0		4 10	1	150	220	270	310	350	380	410	440	470	490	520	540	560	580	600
6	8 15	6 10	6 0	4 5	8 15	7 0		5 0	1¼	220	320	390	450	500	550	590	640	670	710	750	780	810	840	870
7	9 5	7 10	6 15	4 10	10 0	8 0		6 0	1¼	340	430	530	610	680	750	820	870	920	970	1,020	1,060	1,110	1,150	1,190
8	12 0	8 15	8 5	6 0	12 10	9 10		7 0	1½	400	560	690	800	890	980	1,060	1,130	1,200	1,270	1,330	1,390	1,450	1,500	1,550
9	13 0	9 15	9 5	7 0	14 0	11 0		8 0	1½	500	720	880	1,010	1,130	1,240	1,340	1,440	1,520	1,610	1,680	1,760	1,830	1,900	1,970
10	15 0	11 15	10 10	8 5	16 10	12 10		9 0	2	620	880	1,080	1,250	1,420	1,540	1,660	1.770	1.930	1,980	2,080	2,170	2,290	2,350	2,430
11	16 0	12 15	11 10	9 5	18 0	14 0		10 0	2	760	1,070	1,310	1,520	1,700	1,860	2,010	2,150	2,280	2,400	2,520	2,630	2 740	2,840	2,940
12	19 0	13 15	12 15	10 10	20 0	16 0		12 0	2¼	900	1,280	1,560	1,830	2,060	2,210	2,390	2,560	2,710	2,860	3,030	3,130	3,260	3.380	3,500
13	22 0	15 15	15 0	12 15	24 0	18 0		14 0	2¼	1,060	1,500	1,830	2,100	2,340	2,600	2,800	3,000	3,180	3,350	3,500	3,650	3,850	3,950	4,040
14	26 0	18 0	18 0	14 10	27 0	20 0		16 0	2½	1,230	1,740	2,000	2,450	2,730	3,000	3,200	3,450	3,650	3,890	4,050	4,250	4.450	4,650	4,790
15	28 0	19 10	21 0	16 0	30 0	22 0		18 0	2½	1,400	1,990	2,400	2,800	3,150	3,460	3,740	4,000	4,240	4,470	4,690	4,900	5,090	5,200	5,400
16	31 0	21 15			32 0	23 0			2¾	1,600	2,270	2,750	3,200	3,600	3,940	4,250	4,550	4,850	5,080	5,350	5,570	5,800	6,020	6,220
17	34 0	23 10			35 0	25 10			2¾	1.800	2,560	3,120	3,620	4,050	4,450	4,800	5,130	5,450	5,740	6,020	6 290	6 540	6,790	6,840
18	37 0	26 0			38 0	28 0			2¾	2,030	2,870	3,500	4,060	4,540	4,990	5,380	5,760	6,110	6,430	6,750	7,050	7.340	7,630	7,920
19	40 0	29 0			41 0	31 0			2¾	2,260	3,200	3,900	4,520	5,050	5,560	6,000	6,410	6,800	7,170	7,320	7,860	8,180	8,490	8,800
20	44 0	32 0			45 0	34 0			3	2,500	3,550	4,340	5,000	5,600	6,160	6,650	7,110	7,540	7,950	8,340	8,700	9,060	9,400	9,740

To find the size of an injector necessary for a stationary boiler fed with fresh water, multiply the nominal horse power by 12.5; then in the column headed by the working pressure of the boiler from which the steam will be supplied to the injector, find the number of gallons obtained, or if the exact number cannot be found, take the next highest, and the injector opposite this is what is required. For marine boilers multiply by 18.5 instead of 12.5, to allow for blowing off brine, &c.

For description of these injectors, see page 31.

The cost of packing and delivery in London, Liverpool, and Hull, is about 5 per cent. on the above prices.

INJECTORS FOR BOILER FEEDING, Fig. 274. The prices and particulars will be found on the preceding page. The other injectors referred to vary slightly in detail and price, but not sufficiently to make it necessary that each class should be illustrated. Thus, Classes H and I have self-contained steam valve and back-pressure valve, whilst A and B have the former but not the latter. The injector costs less than a pump to deliver a corresponding quantity, and having no parts in motion the wear and tear is very small. They are entirely independent of the engine, therefore the boiler can be fed whilst the engine is standing, which is often a great convenience. The steam employed in working the injector is returned to the boiler in a condensed form, with the feed water, raising its temperature and preventing unequal expansion, and causing it to enter the boiler in a continuous stream. In fixing injectors the following rules may be found useful. The pipes connecting the injector to the boiler should be of the diameter mentioned in the lists. Injectors H and A may be placed above or below the water supply, but I and B must be below or on the same level. They may be fixed either horizontally or vertically. The nut of the water-regulating wheel must be kept moderately tight, to prevent the wheel being accidentally moved from its proper place. The water supply pipe should have a rose on the end of it, and care must be taken that this pipe is air tight. As an extra precaution, a back-pressure valve should be placed on the delivery pipe, between the injector and boiler, also a regulating valve on the steam supply pipe; the latter is a necessity in Class I. When it is desired to start feeding, open the valves or cocks connecting the injector with the boiler, then open the water supply pipe to the extent required by the pressure in the boiler. The amount of water fed may be increased by opening both the steam and water supplies.

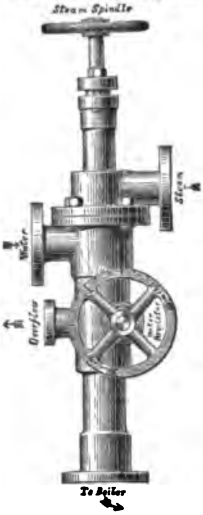

Fig. 274.

EJECTORS FOR RAISING WATER AND OTHER FLUIDS. These are sometimes called elevators or ejectors, and are suitable for raising water, grain, liquid clay, pulp, or chemicals, and many are now doing such work most satisfactorily. Four classes of ejectors are tabulated below. Class L are for both lifting and forcing; they will lift from 6 to 20 feet according to their size, and force about 1 foot high for each pound of steam employed. Class K must not be placed more than from 2 to 5 feet above the liquid to be lifted, and will force to the same height as Class L with equal steam pressure. Classes M and N are intended for great heights, and will force about 3 feet high for each pound of steam; but whilst those of the M class will lift the same height as the L class, Class N will force only the water running into it.

PRICES OF EJECTORS.

Size of Ejector in Millimetres.	Prices with cast-iron case and brass nozzle.				Internal diameter of steam pipe in inches.	Internal diameter of water pipe in inches.	GALLONS DELIVERED PER HOUR AT PRESSURES GIVEN.								
	Class L.		Class K.				20lbs.	30lbs.	40lbs.	50lbs.	60lbs.	70lbs.	80lbs.	90lbs.	lbs. 100
	£	s.	£	s.											
4	2	5	1	10	¾	1	168	204	240	264	288	312	336	360	372
6	3	15	2	10	¾	1¼	384	468	540	600	660	708	768	804	852
9	5	5	3	10	1	1½	864	1056	1212	1356	1488	1608	1728	1824	1932
12	8	5	5	10	1¼	2	1536	1872	2196	2472	2652	2868	3072	3252	3432
15	12	15	8	10	1¼	2½	2388	2880	3360	3780	4152	4488	4800	5088	5364
20	16	10	11	0	1½	3	4260	5208	6000	6720	7392	7980	8532	9048	9540
	Class M.		Class N.												
	£	s.	£	s.											
4	4	10	3	0	¾	1	168	204	240	264	288	312	336	360	372
6	5	10	3	15	¾	1¼	384	468	540	600	660	708	768	804	852
9	8	10	5	10	1	1½	864	1056	1212	1356	1488	1608	1728	1824	1932
12	12	0	8	10	1¼	2	1536	1872	2196	2472	2652	2868	3072	3252	3432
15	17	0	12	0	1¼	2½	2388	2880	3360	3780	4152	4488	4800	5088	5364
20	22	0	17	0	1½	3	4260	5208	6000	6720	7392	7980	8532	9048	9540

The above are the prices at the works, and do not include 5 per cent. for packing or delivery.

MACHINERY FOR DRAINAGE AND IRRIGATION. The remains of extensive works still in a high state of preservation, although they have for centuries been exposed to neglect and frequently to wanton injury, afford striking evidence of a high order of constructive skill, and of the importance attached to works of this character at comparatively remote periods.

In more modern times the sanitary and commercial value of such works has, until recent years, been but little considered; now, however, we see that in northern Europe large sums of money may be profitably invested in artificially draining marshy or submerged land, so as to render it available for agricultural purposes, whilst in the south of Europe, India, Egypt, &c., the most improved machinery for irrigation is a commercial necessity.

The mechanical appliances in general use for both the purposes referred to, are illustrated and described in the following pages.

Many good illustrations of the commercial results obtained under various systems of drainage are to be found in this country; one of the most remarkable being that afforded in "The Fens," now a well-drained and highly cultivated district, although many now living remember this large tract of country as marshy, and for the most part almost worthless land.

Much more striking examples, however, of the immense addition which may be made to the area of cultivable land yielding a satisfactory return on the capital invested, are to be found in Holland; and to that country must be ascribed the credit of showing that by indomitable perseverance and a judicious outlay of capital, pumping machinery may be profitably employed in reclaiming large tracts of submerged land, whereby the producing power of the country is increased and the sanitary conditions greatly improved. One of the earliest examples of successful undertakings of this kind on a large scale, and perhaps the best known, is the reclamation of the land once covered by the "Haarlem Meer" in Holland. The largest steam cylinders ever made were employed to drain this lake, the area of which was about 45,000 acres, and the average depth about 11 feet. The engines have two cylinders, one within the other; the outer cylinder is 12 ft. diameter, and is provided with an annular piston having four piston rods; the inner cylinder is 7 ft. diameter. These immense engines work eleven pumps fixed in a circle round them, and lift the water into the canals which are constructed for carrying it away. The engines and pumps are capable of raising nearly one million tons of water in 24 hours.

WINDMILLS. Both in this country and in Holland windmills were formerly much used for working drainage pumps. This is, of course, a cheap motor, but experience has shown that the power is too variable to be relied upon for keeping the water at a certain level, which is essential for successful agricultural operations; hence many of the older windmills have been abandoned and replaced by steam-engines, or, if the windmills are retained, they are only used occasionally. The cost of maintenance of old mills, however, is so heavy, that it is often found more economical to take them down and work the pumps by steam. Even in countries such as Egypt, where coal costs from £2 to £3 per ton, or even more, and where there is a steady breeze for several hours almost every day, the windmill is too uncertain a motor for irrigation, and steam power is almost universally employed. Many other instances might be adduced, but the two extremes, Holland, where coal is relatively cheap, and Egypt, where it is dear, will probably suffice to show that there are comparatively few conditions under which wind power can be economically employed for drainage or irrigation.

SCOOP WHEELS. Fig. 286 is an example of this class of machinery, which is especially adapted *for low lifts*. The slow speed of working and the ample wearing surfaces are in favour of a low cost of maintenance; the height of lift referred to in the illustration and description is probably about the maximum for which a scoop wheel can be employed with true economy, and then only if it has to work during a great part of the year. If there are long intervals when the machinery is not required, a centrifugal pump will answer every purpose, and the first outlay for it in buildings, foundations, and machinery, will be less than for a scoop wheel of equal capacity.

SCREW PUMPS. These were formerly, and still are, much used for low lifts, and if roughly constructed they are inexpensive; but, as is well known, the per centage of duty in proportion to the power exerted is so low, that this system can rarely be economically adopted; whilst if constructed on the scientific principles described in an able pamphlet written several years ago by Mr. Wilfred Airey, B.A., the screw pump is almost as costly as a scoop wheel. Having regard to all the circumstances, it has not been considered necessary to give examples and details of the cost of these pumps. Many screw pumps are still working, but in modern practice a scoop wheel or centrifugal pump is preferred.

CENTRIFUGAL PUMPS. This class of pumping machinery is invaluable for raising a large volume of water to a moderate height. The limit at which it can be economically used depends upon circumstances which are constantly varying. It may be as much as 40 or 50 ft., but may be fixed under ordinary conditions at or below 25 ft. from the level of water at the suction to the point of discharge. Having regard to the *total* cost of the machinery delivered and erected ready for work, including the cost of foundations and buildings, when working within the limit last named, centrifugal pumps will be almost (if not quite) as economical as reciprocating pumps, and the first outlay will be much lower for the centrifugal than for the reciprocating system.

The machinery illustrated, Figs. 275 and 276, was supplied by the Author's firm for draining a large tract of land in Holland, and consisted of four centrifugal pumps on the whirlpool system, each with suction and delivery pipes 30 in. diameter, the outer casing being 9 ft. 6 in. diameter. Each pump is capable of lifting 90,000 tons of water in 24 hours to a height of 5 metres, or 16 ft. 4 in.

The power for driving the pumps is obtained from a pair of horizontal high pressure expansive and condensing engines, the steam cylinders being 24 in. diameter, 48 in. stroke, steam jacketed, and felted and lagged. The engines are coupled to a wrought-iron crank shaft 11 in. diameter at the centre, on which is keyed a spur fly-wheel 14 ft. 5 in. diameter at the pitch line and 14 in. wide; this gears with a pinion keyed on a countershaft running the whole length of the pump-house, and transmits motion to the pumps by means of four mortice wheels about 8 ft. diameter, each of which gears into a pinion on one of the pump spindles. The bearings for the counter-shaft and the outer bearings for the pump spindles are carried in pedestals bolted to massive base-plates secured to the bed-plates on which the pumps are fixed, and both the pump pinions and the wheels which drive them work between bearings, as shown in Fig. 275.

The engines above referred to are fitted with Meyer's expansion gear, which is more fully described in connection with the pumping-engine for town supply, Fig. 257. This very efficient form of valve gear is especially useful under the conditions now described, because the engine can be started under a heavy load, and the grade of expansion can afterwards be increased to the highest point at which the engine will work. This necessarily varies as the process of draining the lake proceeds, the height of lift increasing as the water recedes. An efficient expansion gear which can be regulated to the work actually to be performed is, therefore, essential for economy in the consumption of fuel.

The exhaust steam is led to a surface condenser of 6 ft. internal diameter, fitted with 360 wrought-iron tubes 2½ in. internal diameter. Eight of these tubes are utilized as stays for the tube plates. The circulating water is supplied by a centrifugal pump, and this, as well as the air pump, is driven by a separate horizontal engine similar in construction to the main engines already described. The condensing apparatus is not shown in the engravings.

The air-pump is double-acting, 12 in. diameter, 18 in. stroke, and is directly behind the steam cylinder, the piston being attached to the rod of the steam piston. The air-pump valves have india-rubber discs, gun-metal gratings and guards. The air-pump is lined with gun metal, and the steam cylinder is felted and neatly lagged with mahogany, like the cylinders of the main engines. Throughout the whole pumping station every precaution is taken to prevent loss of heat by radiation. A feed water heater on the exhaust pipe heats the feed water to a high temperature before it enters the boilers. A branch is provided on the exhaust pipe in such a position, that in case of accident to any part of the condensing apparatus, by closing one valve and opening another, the engines can be temporarily used at high pressure without the condensers, and the pumping continued. A separate donkey feeding engine is provided, in addition to the feed pumps on the engines. The steam for all the engines is generated in single-flued Cornish boilers. There are four of these in the boiler house; each is 6 ft. external diameter, and 25 ft. long, and has an internal flue 3 ft. diameter, with seven Galloway tubes in each flue. The steam dome is 2 ft. 9 in. diameter, and 2 ft. 9 in. high. The firegrate has a surface of 22·5 square feet. The products of combustion, after traversing the central flue, are divided right and left, return along the sides of the boiler, dip down at the front end, and pass along under the boiler to the chimney in the usual manner. The heating surface is about 528 square feet, but of course it is not all of equal value. The furnace front has a sliding ventilator, and there is an adjustable damper in the flue leading to the chimney. These enable the admission of air to be well regulated. Each boiler has two safety valves, each 5 in. diameter, one being locked up, so that it cannot be tampered with. There is a screw-down stop-cock 6 in. diameter on the top of each dome; each of these is connected by a T-piece with the main steam pipe, which has an expansion joint in it between each pair of boilers. The blow-off cock is in the bottom of front end of boiler, and the feed cock and check valve on the front. Each boiler is provided with a pressure gauge, gauge glass, fusible plug, &c. Owing to the swampy nature of the soil, the pumping station, like many others in Holland, is built on piles, with the brickwork and masonry on the top of them, necessary to give stability to the whole. The building is 107 ft. long by 50 ft. 6 in. wide; the engine and pump room being 63 ft. 9 in. by 48 ft. 6 in. between walls, and the boiler house 39 ft 3 in. by 48 ft. 6 in. A plant of machinery similar to that illustrated, Figs. 275, 276, and described above, would, at the present time, cost about £5,600. This includes all pipes and connections, but not the cost of foundations or erection.

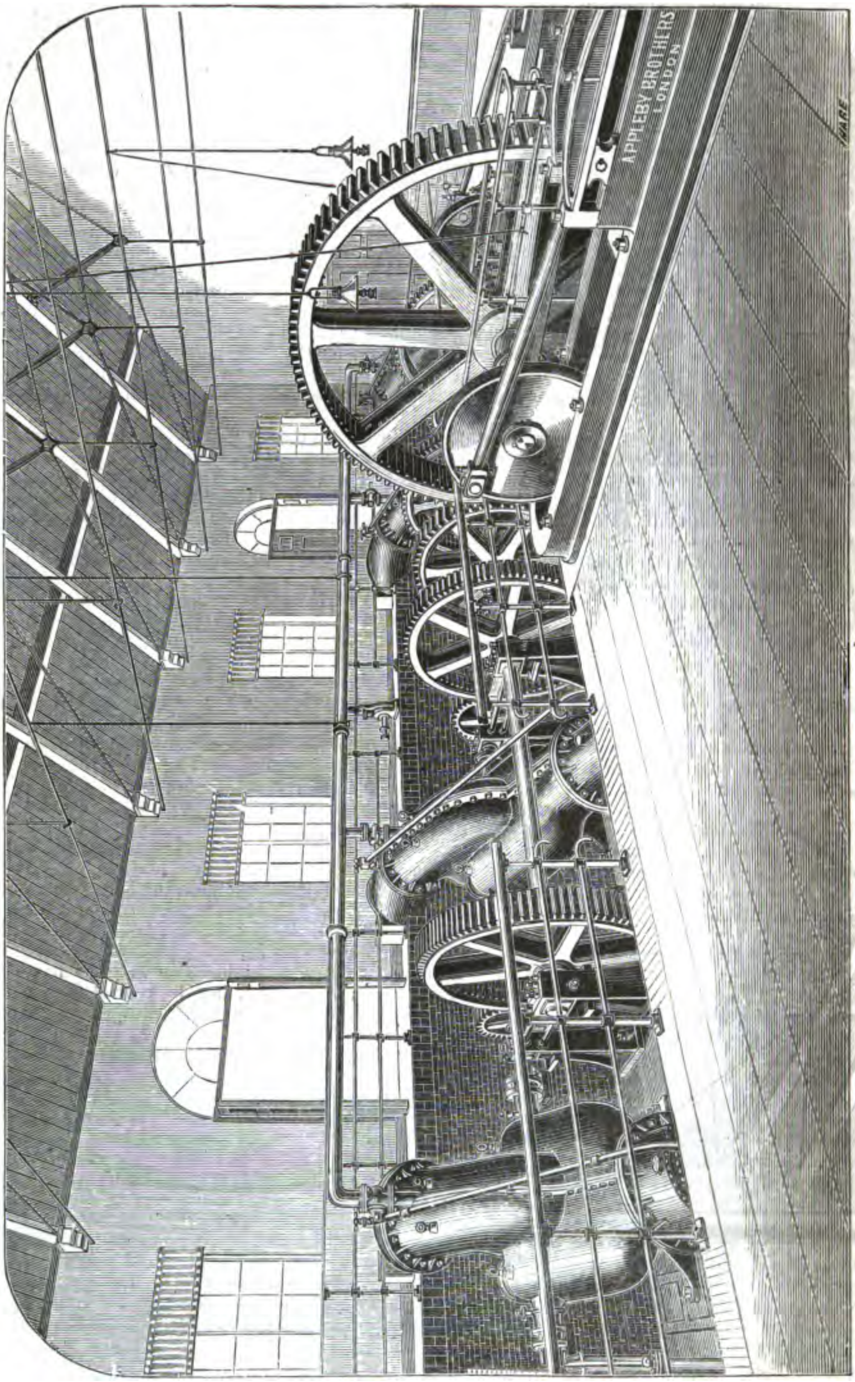

Fig. 275.

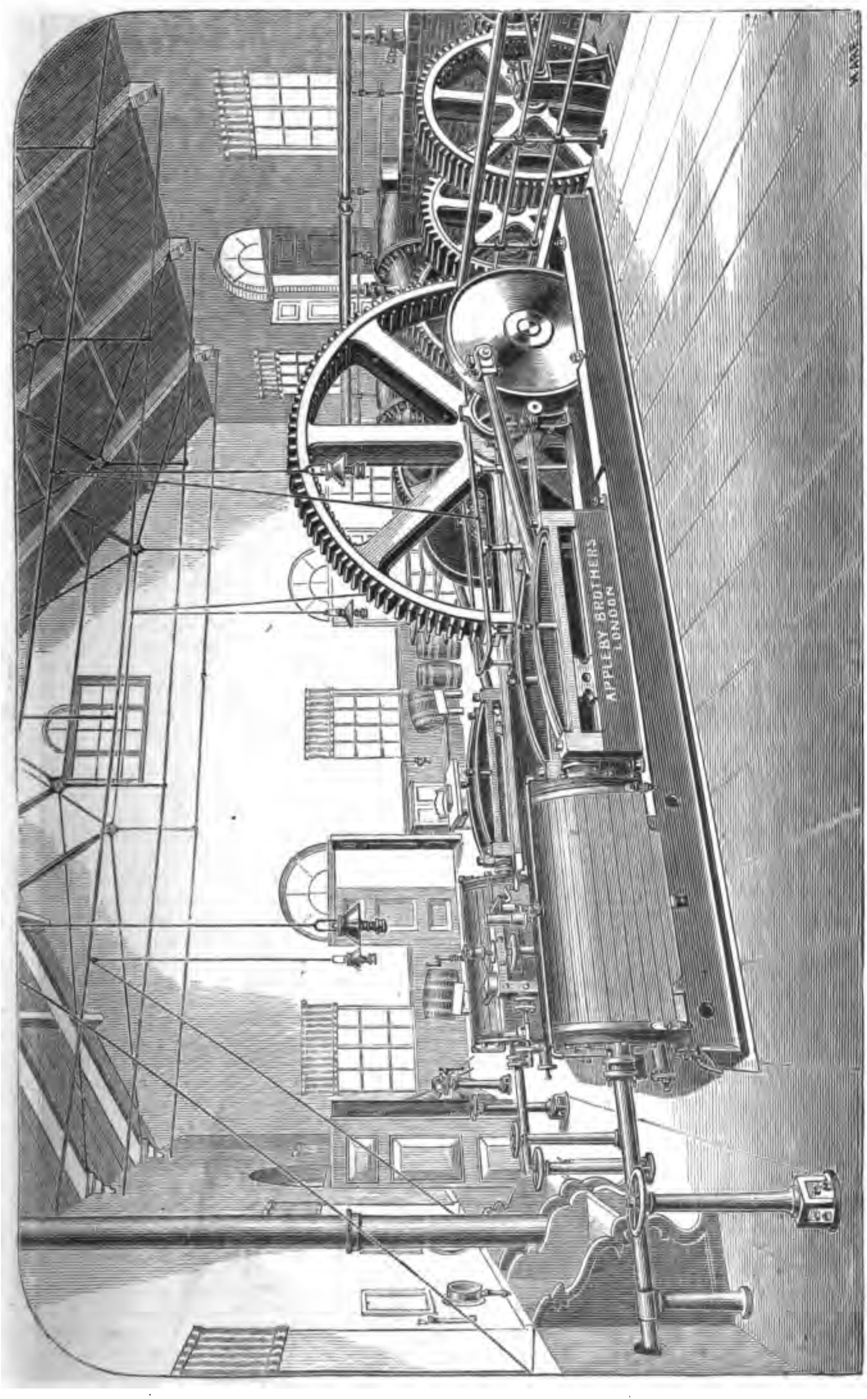

Fig. 276.

The foregoing somewhat minute description will give an idea how large or smaller pumping stations may be laid out, whether for the purpose of drainage or irrigation. In the case described, the pumps discharged into a canal, and the water was carried out to sea. For irrigation, the pumps discharge into a channel at a sufficient height to convey the water by gravitation to the land.

The conditions to be fulfilled by pumping machinery vary so widely both in regard to the quantity of water to be lifted and the height of lift, that it will be of little avail to repeat examples; the cost, however, of a plant of machinery may be pretty closely estimated by reference to the cost of the separate machines and materials.

Centrifugal pumps being continuous in their action produce less vibration than reciprocating pumps, and are for this reason, amongst others, preferred for use where the foundations are in swampy or soft ground.

For temporary work the pumps are often driven by a portable or horizontal high pressure steam-engine, but where economy of fuel and low cost of maintenance are sought, a condensing engine gives excellent results.

Centrifugal pumps with the engine working direct on the pump spindle, especially suitable for floating or graving docks, or contractors' use, are referred to at pages 44 to 46.

COMPOUND ENGINE AND CENTRIFUGAL PUMP, Fig. 277. This compact and efficient arrangement of machinery for irrigation was designed by the Author's firm, and supplied for use in Egypt. The whole arrangement is self contained, all the various parts being attached to one deep massive cast-iron bed-plate, which carries the crankshaft pedestals and the pedestals for pump spindle. The engines are of the vertical type, compound and condensing. The high pressure cylinder is 7 in. diameter and the low pressure cylinder 14 in. diameter, so that the areas are in the proportion of 1 to 4, and both have a piston stroke of 14 in. The valve boxes are between the cylinders, a cover being provided at the top for examination, &c., and the cylinders and valve boxes are felted, and lagged with polished mahogany. The valve of the low pressure cylinder is the ordinary D valve, but the high pressure engine is fitted with a Mayer's expansion gear, whereby the expenditure of steam can be regulated in accordance with the height to which the water has to be pumped. Each of the cylinders is mounted on, and cast with a pair of strong iron standards, which also form the guides for the cross-head, a portion of them being bored for this purpose. The pistons are cast iron, fitted with rings and springs, and secured to the piston rods by nuts; the piston rods, which are steel, turned taper at the piston end, and shouldered down, and cottered to cross-heads at the other end. The cross-heads are cast iron fitted with loose faces. The connecting-rods are of hammered scrap iron, fitted with adjustable gun-metal bearings at both ends; the crankshaft end having a marine pattern head. The valve rods are steel and guided beyond the glands, the eccentric rods are of wrought iron, and the eccentric straps of gun metal. The crankshaft is bent out of best hammered scrap iron, and runs in three pedestals fitted with adjustable-gun-metal bearings. The jet system of condensation is used, the condensing chamber being formed in the bed-plate. The cock for regulating the supply of injection water, and the air pump are in the foreground of the engraving, the latter of the ram and bucket principle, is driven by a crank arm, and pin on the end of the crankshaft, the valves being india-rubber discs working on gun-metal gratings. A spur fly-wheel is keyed on to the end of the crankshaft, this drives a pinion on the pump spindle, so that the pump disc makes three revolutions for each double stroke of the engines; this enables the engines to maintain a very moderate speed and obviates the necessity of the constant repairs, which frequently are a source of inconvenience in very high speeded engines. The pump has 12 in. suction, and delivery pipes, the suction pipe having a foot valve on it, and the delivery being provided with a sluice valve. The pump disc makes about 600 revolutions per minute, and delivered 2,500 gallons per minute to a height of 20 feet. Small covers are provided on each side of the pump casing, so that the disc may be examined without taking the pump to pieces. The steam for this pumping engine is generated in a multitubular semi-fixed boiler; this boiler is made with an extra large firebox, with Head and Schimeoth's apparatus for burning straw, driven from the engine by means of a countershaft and belting. A small iron tank is provided as a hotwell from which the feed water is taken; the feed pump is on the engine driven from one of the valve eccentrics in the usual way. In addition to the hot well tank there is a large tank to contain a supply of water for injection or for priming the pump at first starting; this tank not being always necessary is not included in the prices given. Pumping engines of this design (Fig. 277) work with very low consumption of fuel, and are well adapted for graving, floating docks, drainage, irrigation, &c., in countries where fuel is expensive; but where fuel is comparatively cheap, or for temporary or intermittent use, it may be unnecessary to adopt the compound system, and pumps driven by high pressure non-condensing single cylinder engines or single cylinder condensing engines may be used with advantage. These although less economical in working are considerably less in first cost, and occupy rather less space. Prices of all three classes of centrifugal pumping engines will be found in the subjoined list. The cost of steam piping or cocks, feed piping, &c., or hot wells, is not included. In the list a height of lift of

20 feet is assumed. If steam is to be taken from an existing boiler, the working pressure must be stated. Boilers are not included in the list, but prices of nearly every variety will be found on pages 54 to 64 in Section 1, and the cost of steam and feed piping may be obtained by reference to pages 148 to 154.

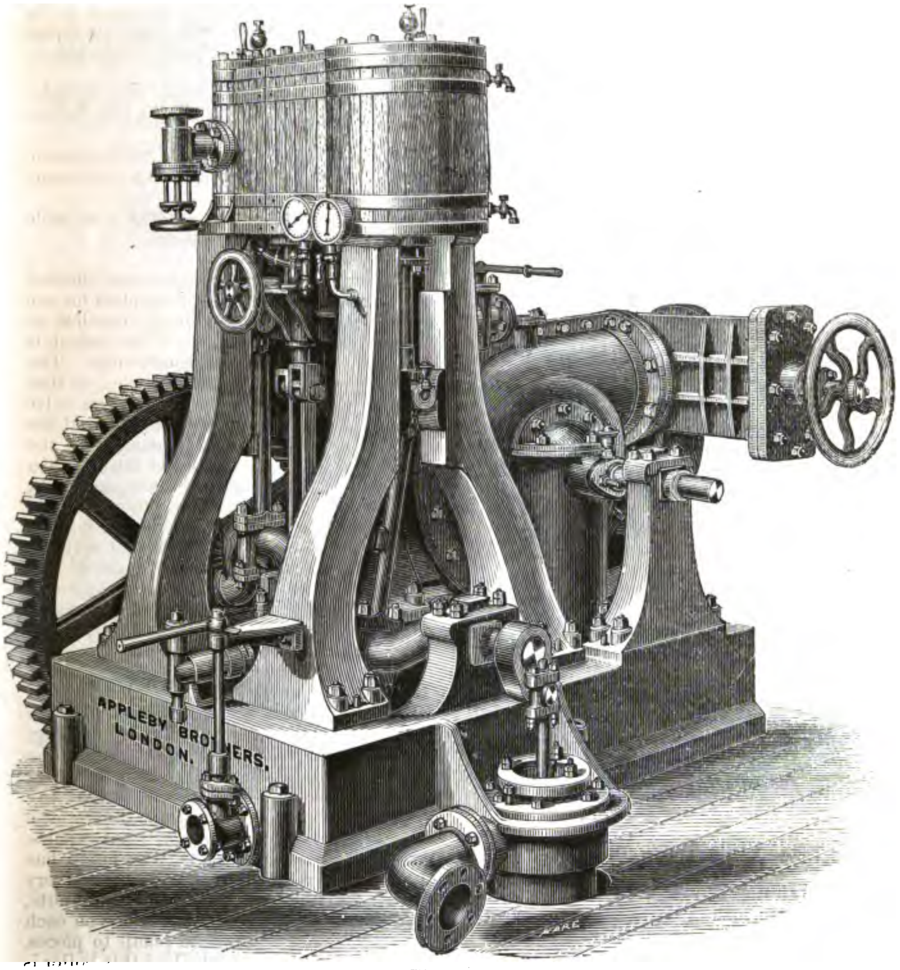
APPLEBY BROTHERS, LONDON.

Fig. 277.

PRICES OF COMBINED ENGINES AND CENTRIFUGAL PUMPS, FOR 20 FEET LIFT.

Diameter of pump pipes in inches ..	6	8	10	12	15	18	24
Gallons pumped per minute	500	750	1000	1500	2700	3300	7600
Price of single cylinder high pressure engine and pump	£140	£180	£220	£250	£300	£350	£550
Price of double cylinder high pressure engine and pump	£250	£300	£375	£450	£530	£650	£850
Price of compound engine and pump .	£275	£330	£420	£495	£590	£705	£920
Extra for condenser, suitable for either type	£30	£35	£40	£50	£65	£80	£100

HIGH PRESSURE PUMPING ENGINE. A neat and compact arrangement of a horizontal single cylinder non-condensing pumping engine, designed by Messrs. Lawrence and Porter, is illustrated below (Fig. 277*). The features of novelty are, that the centre of the pump spindle is raised above the centre line of the engine sufficiently to clear the motion of the engine, and thus considerably to shorten the bed-plate casting, although giving a level base to the whole; in most other designs the pump projects below the bed-plate casting.

The pump is constructed with a loose cover, to admit of the disc being removed from the pump casing for examination or cleaning, without disturbing the connections or the driving gear; this is clearly shown in the engraving, as well as the small air pump for charging the centrifugal pump. This air pump is driven from an eccentric pin on the end of the crank-shaft, working in a die and slotted cross-head, guided by the two round guide-rods; a clutch and lever moved by the hand-wheel and screw takes this out of gear when the pump is charged.

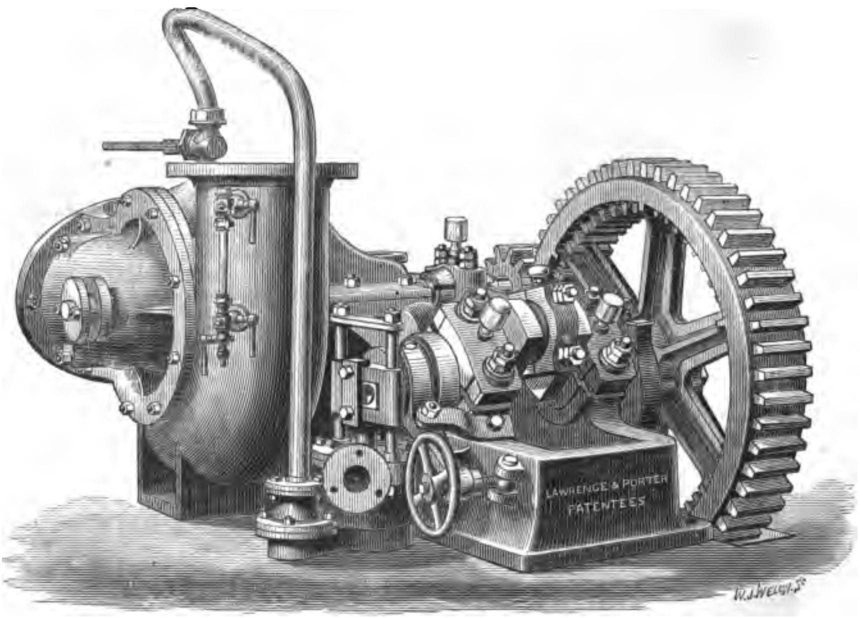

Fig. 277.*

The steam cylinder is steam jacketed, and the whole of the motion work, bearings, crank, shaft, &c., are made very massive; proper provision is made for the lubrication of the working parts, these being essential features for high speed engines of this kind which develop usually about six times their nominal horse-power. It will be observed that the pump is geared up to the engine by mortice gearing in the ratio of about 3 to 1, thus enabling a small diameter of pump disc to be used with a moderate piston speed. Direct experiment has proved that a higher duty can be obtained with a small disc running at a given speed of periphery, than with a larger disc the periphery of which runs at equal speed; this may possibly be accounted for by the smaller amount of skin surface presented to the action of the water by the small pump and disc.

The arrangement of driving by wheel and pinion has been adopted, because with a moderate piston speed the machinery will run for a very long time with only ordinary attention, whereas if the engines drive direct on the pumping spindle, whether for the purpose of drainage, irrigation, or circulating pumps for the marine engines, they should be under the charge of a highly skilled and careful engineer who will at once attend to the repairs which are incidental to extreme speeds of working. This entails a large amount of extra duty from the Chief Engineers, and they often say that the machinery for the surface condensers require far more attention than the large engines to be maintained in satisfactory working order. For prices see the preceding page.

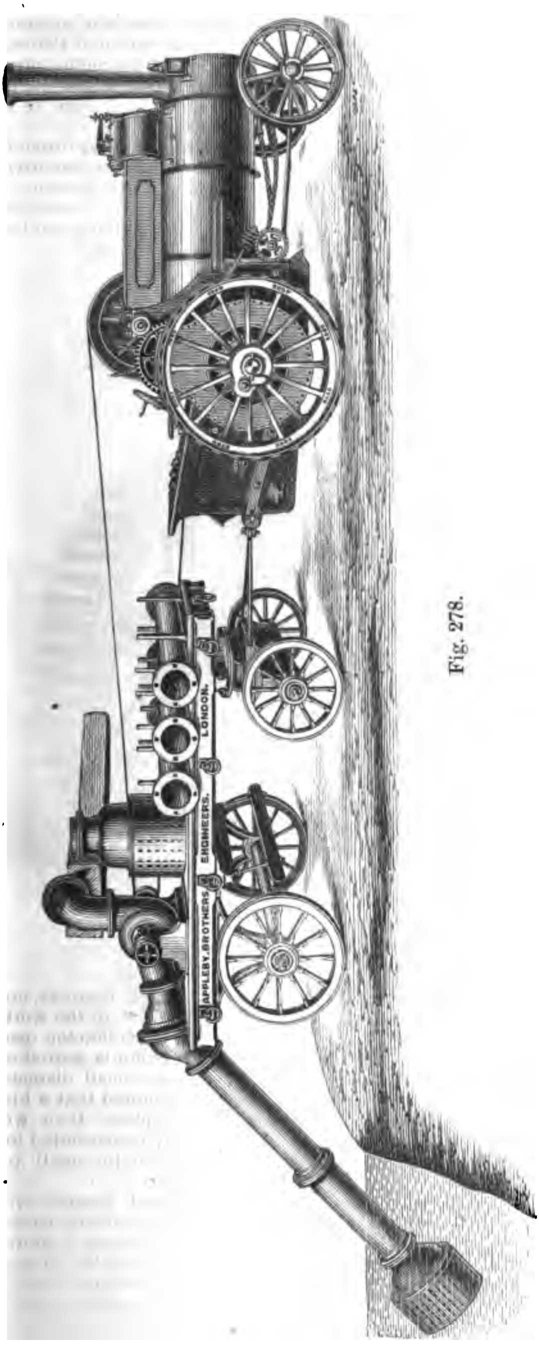
APPLEBY, BROTHERS, ENGINEERS, LONDON.

Fig. 278.

PORTABLE MACHINERY FOR IRRIGATION (Fig. 278). — This plant of machinery is admirably adapted for drainage or irrigation; it consists of a traction engine and a centrifugal pump on a suitable truck. The traction engine serves the double purpose of moving the centrifugal pump from place to place, and driving it when fixed ready for work. Prices and other particulars relative to traction engines, will be found on pages 26 to 28, Section 1. The engine is entirely under the control of one man, and can be easily detached from the truck carrying the centrifugal pump, and used for moving or driving other machinery. The centrifugal pump is fixed on the end of a large truck mounted on ordinary road wheels, the smaller or front pair of wheels being provided with locking gear, to enable the truck to pass round small curves; sufficient room is allowed on the truck to admit of pipes, foot valves, tools, &c., being placed on it. The pump is represented in the engraving as employed in pumping from a river and delivering the water into an open wooden trough for purposes of irrigation. The suction pipe is provided with a ball and socket joint, which admits of the pipe being placed at any required angle; the lower end of the suction pipe has a foot valve and windbore or strainer. Three lengths of pipe for lengthening the suction or delivery and a spare windbore are shown on the truck. The pump is driven by a leather or india-rubber belt from the flywheel of the traction engine. The value of this plant of machinery, consisting of an eight horse-power traction engine; 10 in. centrifugal pump with 1 foot valve and windbore; 30 feet of wrought-iron pipes with cast-iron flanges; bolts, nuts, and washers for joints; truck for pump and 50 feet of suitable leather belting, is £765.

To estimate the engine power necessary to perform the work, divide the number of gallons per hour by 99,000, and multiply the result by the height in feet the water has to be lifted (the boiler pressure being assumed at 60 lbs. per square inch). The nominal engine power being thus ascertained, the cost of the engine and boiler will be found in Section 1.

PORTABLE ENGINE AND CENTRIFUGAL PUMP. The pump is fixed on a staging over a stream, and is driven by a portable engine. This and similar arrangements are applicable to a great variety of purposes, amongst which may be mentioned irrigation, drainage, sheepwashing, emptying docks, dams, &c., and will be found particularly useful to those engaged in agricultural pursuits.

The engine is of the type fully described on pages 28 and 29, Section 1, and is available for many purposes when not required for pumping. The pump is so arranged that by the removal of a cover, without disturbing the suction and delivery pipes, the disc can be examined, and cleared of any weed or other obstructions which may have choked it.

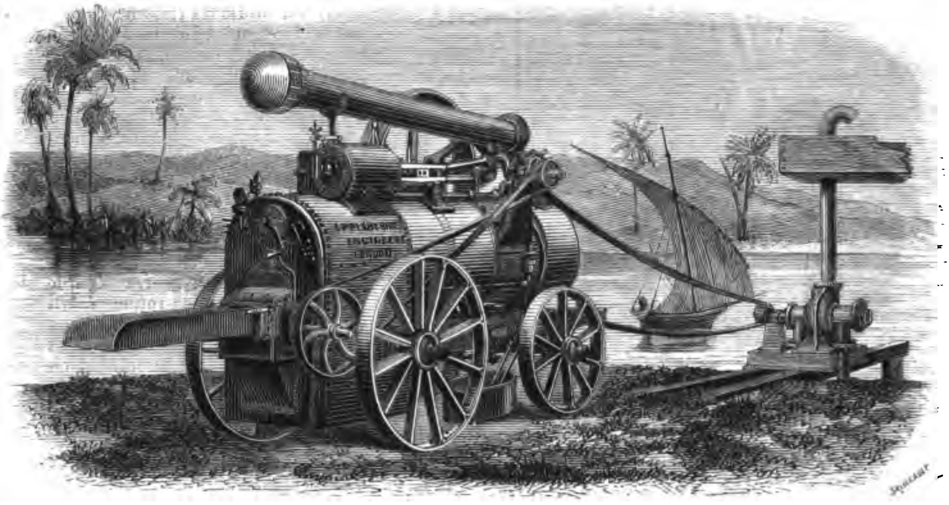

Fig. 279.

The illustration, Fig. 279, is from a photograph of pumping machinery extensively used for irrigation in Egypt and other countries. The boilers have fireboxes considerably larger than the ordinary portable engines, and where coal is expensive, as in Egypt, and there is an abundant supply of cotton stalks, maize, &c., great economy is obtained by feeding this vegetable matter into the firebox by the patent straw-burning apparatus, driven by a strap from the crank shaft as shown in the engraving. The travelling wheels are made entirely of iron, and cannot be affected by excessive heat or the attack of insects. The pump shown in the engraving has double suction pipes, but the risk of leakage of air arising from bad joints and some in skin friction in the pipes, renders this construction less desirable than that referred to under Fig. 280. The pipes are frequently made entirely of wrought iron, with a view of saving weight, and avoiding the inconvenience caused if a pipe is broken. The disc is accessible for examination without disturbing any of the joints.

The vertical portable engines shewn on pages 30 to 32, Section 1, can be employed for driving a centrifugal pump in a similar manner to that indicated in the engraving, and will not only be cheaper, but in situations where foul feed water must be used, they are strongly recommended.

PRICES OF PORTABLE ENGINES AND CENTRIFUGAL PUMPS, Fig. 279.

FOR LIFTS NOT EXCEEDING 12 FEET.

Diameter of pump pipes in inches	6	8	10	12	15	18
Horse power of portable engine	2½	3	6	8	12	18
Number of gallons delivered per minute ..	600	900	1600	2000	3500	5000
Price of portable engine	£105	£125	£180	£210	£280	£410
„ centrifugal pump	£25	£34	£40	£50	£90	£115
„ suitable pipes per foot	5/-	8/-	12/-	18/-	25/-	30/-
„ 50 feet driving belt	£5	£6	£8	£11	£15	£18

Packing and delivery about 4 per cent.

UNI CALIF

For Lifts above 12 but not exceeding 25 Feet.

Diameter of pump pipes in inches	6	8	10	[illegible]	15	18
Horse power of portable engine	4	6	10	[illegible]	20	30
Number of gallons delivered per minute ..	500	800	1500	1800	[illegible]	4500
Price of portable engine	£150	£180	£240	£340	[illegible]	£640
" centrifugal pump	£25	£34	£40	£60	[illegible]	£115
" suitable pipes per foot	5/-	8/-	12/-	18/-	25/-	30/-
" 50 feet driving belt	£5	£6	£8	£11	£15	£18

Packing and delivery about 4 per cent.

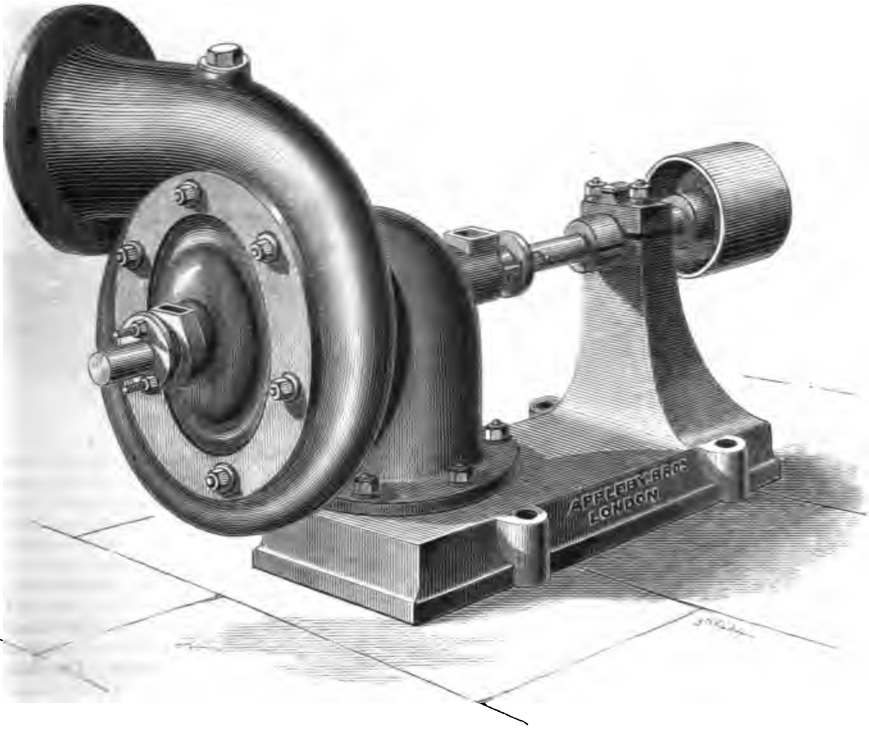

Fig. 280.

CENTRIFUGAL PUMPS are so well known and have been so thoroughly tested that but little description will be necessary either as regards the construction or the numerous conditions under which this class of pumping machinery may be profitably employed; indeed, scarcely a large public work has been carried out for many years past without the aid of centrifugal pumps of the type illustrated, Fig. 280.

Unquestionably the useful effect obtained relatively with the power employed is far less with high lifts than with low lifts; and although centrifugal pumps have been used for forcing water a height of more than 100 feet, this is far in excess of what such pumps ought to be used for, unless there are some special conditions which cannot be conveniently fulfilled by a reciprocating pump.

The centrifugal pump is invaluable for raising liquids containing a large mixture of foreign matter, such as are found in tanneries, paper, dyeing, bleaching, and chemical works, and in many other industrial operations.

If the pump is fixed several feet above water level it is often desirable to have a foot or retaining valve on the bottom of the suction pipe; this is useful where the pump is worked intermittently, and has to be "primed" before starting. It is also desirable that there should be access to the disc for the purpose of clearing away any foreign matter, weeds, &c., which have accumulated about the disc; this is provided for by the doors at one side of the pump case, which can be taken off, and the disc cleared of obstructions without disturbing the suction or delivery pipe.

This class of pump is, as is well known, largely used in connection with surface condensers, generally driven by a separate engine as described at pages 36 to 38, both for land and marine engines.

Reference is made at pages 44 to 46 to the advantages obtained in the use of centrifugal pumps in connection with floating docks.

The number of gallons delivered per minute, and the height to which water can be raised, depends upon the speed at which the pumps are run. The quantity given in the subjoined list is by no means the maximum.

PRICES OF CENTRIFUGAL PUMPS, Fig. 280.

Diameter of suction and delivery pipes, inches	3	4	6	8	10	12
Number of gallons per minute	75	200	500	800	1500	1800
Price of pump complete	£12 10 0	£16 0 0	£25 0 0	£34 0 0	£40 0 0	£50 0 0
" foot valve and grating	£1 12 6	£2 5 0	£4 0 0	£5 10 0	£6 10 0	£8 10 0
Price of 3 ft. length of cast flanged pipe ..	£0 7 6	£0 9 0	£0 16 6	£1 7 6	£2 0 0	£2 17 6
Price of 6 ft. length of cast flanged pipe ..	£0 11 0	£0 16 0	£1 7 6	£2 7 6	£3 8 0	£5 0 0
Price of 9 ft. length of cast flanged pipe ..	£0 16 0	£1 5 0	£2 0 0	£3 8 0	£4 10 0	£6 10 0
Price of flanged pipe, bend 90°	£0 5 10	£0 7 7	£0 15 0	£1 10 9	£1 19 6	£2 13 6
Price of set of bolts and nuts for joints ..	£0 0 10	£0 1 3	£0 1 6	£0 2 0	£0 4 6	£0 5 3
Price of india-rubber joint rings, each ..	£0 0 8	£0 1 3	£0 1 3	£0 1 9	£0 3 0	£0 4 0

Diameter of suction and delivery pipes, inches ..	15	18	21	24	30
Number of gallons per min.	3000	4500	5500	6750	8000
Price of pump complete ..	£78 0 0	£100 0 0	£140 0 0	£200 0 0	£270 0 0
" foot valve and grating..	£12 0 0	£16 0 0	£18 0 0	£25 0 0	£35 0 0
Price of 3 ft. length of cast flanged pipe	£3 17 6	£4 14 0	£5 0 0	£5 10 0	£6 15 0
Price of 6 ft. length of cast flanged pipe	£6 2 0	£7 11 6	£9 0 0	£10 10 0	£13 10 0
Price of 9 ft. length of cast flanged pipe	£9 3 0	£11 3 0	£13 10 0	£15 15 0	£20 5 0
Price of flanged pipe, bend 90°	£3 15 6	£5 10 0	15/-	per	cwt.
" set of bolts and nuts for joints	£0 7 6	£0 8 6	£0 10 0	£0 12 6	£0 15 0
Price of india-rubber joint rings, each	£0 5 6	£0 9 0	..	..	..

Pumps with pipes above 12 inches diameter should have an extra standard and bearing, to give additional support to the pump spindle. Some of the larger sizes may with advantage be driven by two belts, one on each side of the pump, and, where practicable, the three largest sizes should be either driven direct from the engine or by gearing.

PORTABLE CENTRIFUGAL PUMP, Fig. 281. This arrangement is useful for works of drainage or irrigation, when it is necessary to move the pumps from place to place. The pumps can be drawn by horses or bullocks, and when placed in position for work can be driven by a portable or traction engine, or where such power is not available specially designed horse or bullock gear can be used. The construction of the pumps is such that the pipes can be so placed as to deliver the water at almost any angle. If desired, the suction pipes can be fitted with ball and gland, enabling the pipe to be laid at any convenient angle; this, of course, entails a slight increase in cost. The prices in the list do not include shafts or draw poles.

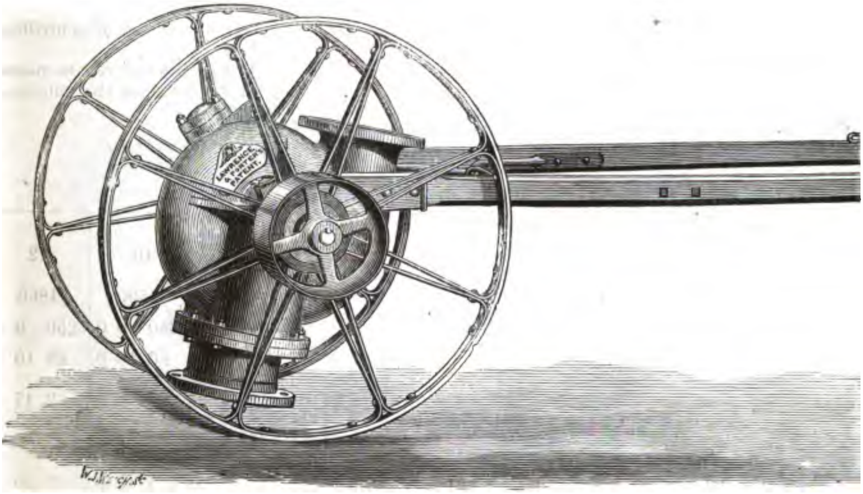

Fig. 281.

The cost of these is about £3 per pump. The arms and rims of the travelling wheels are of wrought iron; the central boss only is made of cast-iron and is carefully bored. These bosses run on the pump spindle and are of extra length, and the diameter of the pump spindle is also increased so that ample wearing surfaces are provided; the construction throughout is strong and compact.

For fixed pumps cast-iron flanged pipes are cheap and easily procured, but for portable pumps wrought-iron pipes (prices for which are given in the subjoined list) are strongly recommended, as they are much lighter and stronger. The bends being small are made of cast-iron.

The quantity of water delivered per minute and the height to which it can be raised depends upon the speed at which the pumps are driven. The quantity given in the subjoined list is by no means the maximum, it may be doubled if desired; but this result will be obtained at some sacrifice in the useful effect of the engine power employed.

PRICES OF PORTABLE CENTRIFUGAL PUMPS, Fig. 281.

Diameter of suction and delivery pipes, ins.	6	8	10	12
Number of gallons per minute	300	600	800	1200
Price of pump complete, as shown	£45	£65	£78	£110
Price of foot valve and grating				
Price of 3 ft. length of wrought-iron pipe ..	£1 15 0	£2 0 0	£2 5 0	£2 10 0
,, 6 ,, ,, ..	£3 0 0	£3 10 0	£3 15 0	£4 0 0
,, 9 ,, ,, ..	£4 5 0	£5 0 0	£5 10 0	£6 0 0
Price of light cast-iron pipe bends ..	£0 15 0	£1 10 9	£1 19 6	£2 13 6
Price of set of bolts and nuts for joint ..	£0 1 6	£0 2 0	£0 4 6	£0 5 6
Price of india-rubber joint rings, each ..	£0 1 3	£0 1 9	£0 3 0	£0 4 0

Packing for shipment varies slightly, but will seldom exceed 4 per cent.

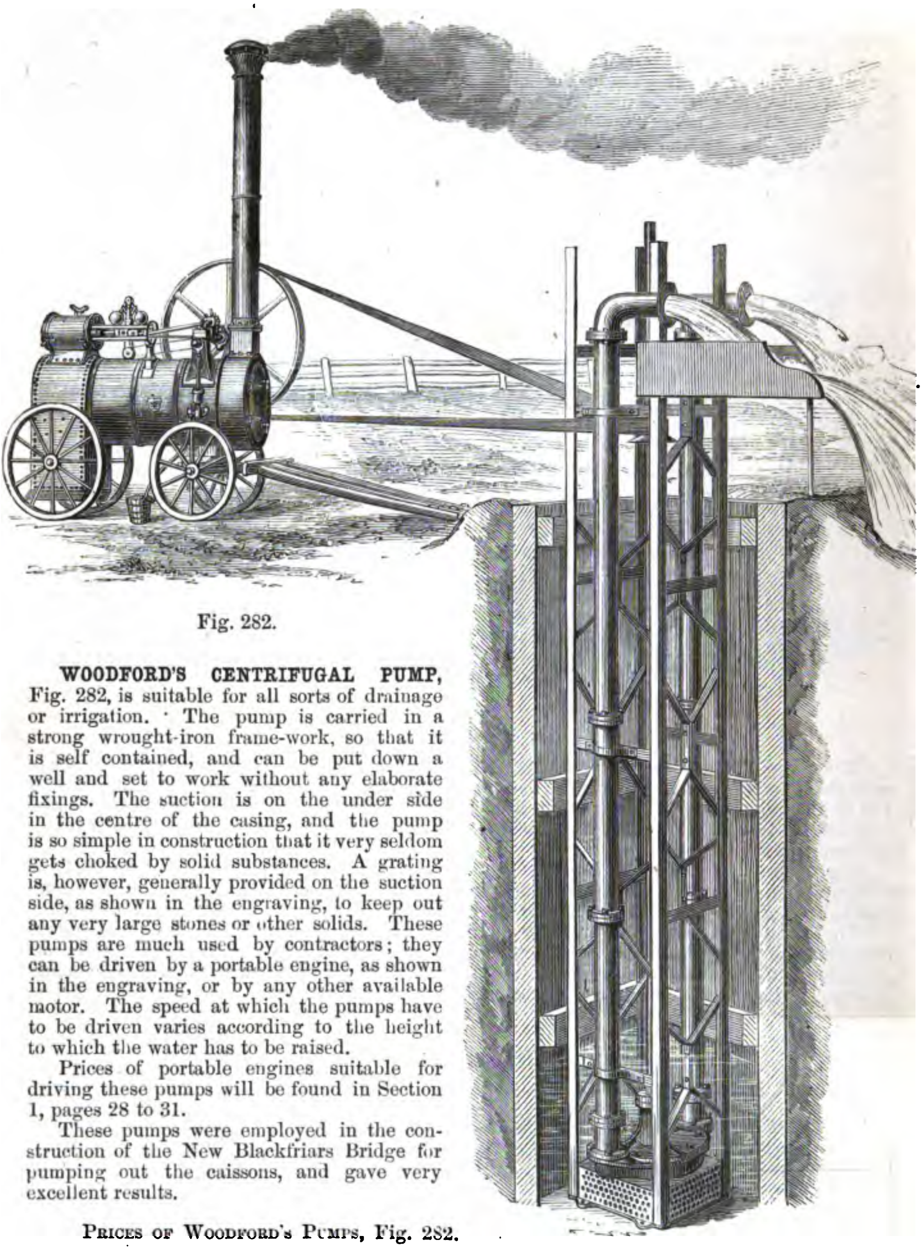

Fig. 282.

WOODFORD'S CENTRIFUGAL PUMP, Fig. 282, is suitable for all sorts of drainage or irrigation. The pump is carried in a strong wrought-iron frame-work, so that it is self contained, and can be put down a well and set to work without any elaborate fixings. The suction is on the under side in the centre of the casing, and the pump is so simple in construction that it very seldom gets choked by solid substances. A grating is, however, generally provided on the suction side, as shown in the engraving, to keep out any very large stones or other solids. These pumps are much used by contractors; they can be driven by a portable engine, as shown in the engraving, or by any other available motor. The speed at which the pumps have to be driven varies according to the height to which the water has to be raised.

Prices of portable engines suitable for driving these pumps will be found in Section 1, pages 28 to 31.

These pumps were employed in the construction of the New Blackfriars Bridge for pumping out the caissons, and gave very excellent results.

PRICES OF WOODFORD'S PUMPS, Fig. 282.

Dia. of pump-pipes in inches	3¼	4½	5½	6¼	8¼	10½	13¼	16
Number of gallons per hour	500	1000	1500	2000	3000	5000	8000	12,000
Price complete for 10 feet..	£42 10	£54 10	£66 10	£85 10	£121 10	£182 0	£285 0	£425
Price for each 9 feet extra..	£9 0	£10 10	£12 15	£13 10	£15 10	£18 10	£21 10	£25

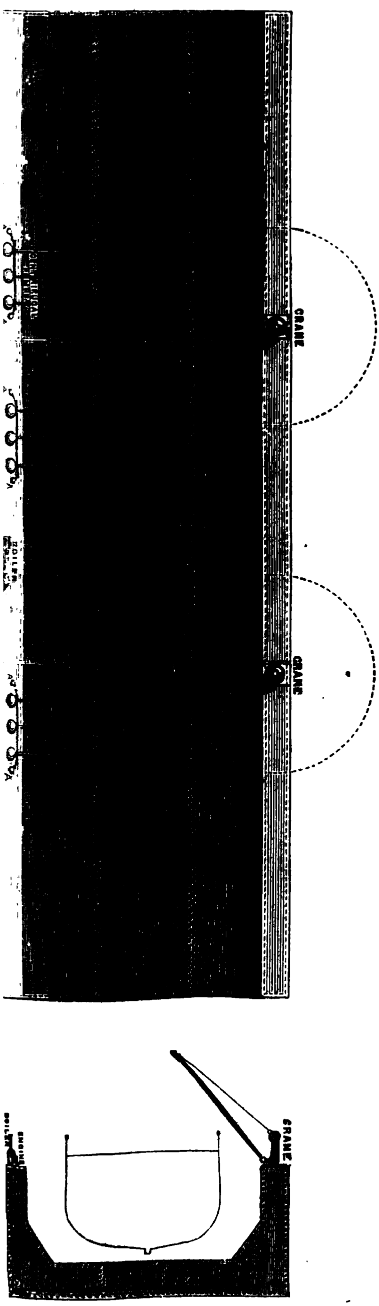

Fig. 283.

PUMPING MACHINERY FOR A FLOATING DOCK, Fig. 283, shows the general arrangement of a floating dock, the machinery for which was supplied by the Author's firm, and Figs. 284 and 285 are the engines and pumps specially designed and made for this dock. The dock is 200 ft. long and 58 ft. wide, and is built entirely of timber; it is divided into nine water-tight compartments, and the dock is manipulated by letting water into or pumping it out of these compartments. It was at first proposed to use three sets of pumps and engines, and arrange pipes and valves in such a manner that each pump should be able to work three compartments of the dock; but by having a separate engine and pump for each compartment it was evident that a better command of the dock could be obtained, and this arrangement was adopted. The pumps are disposed in groups of three, and the arrangement of pipes and valves is such, that each pump can be made to work either of the three compartments belonging to its group. Thus, if one pump is choked or an engine breaks down, the operation of raising or lowering a ship only occupies a rather longer period than if all the pumps are in working order; when it is desired to examine or repair a ship, water is allowed to flow into the compartments of the dock by means of the inlet valves specially provided for this purpose. Each group of pumps has two screw-down valves, 10 in. diameter, with spherical faces; the rods actuating these valves pass up through the dock side to the platform, and all the operations are controlled from one side of the dock. The arrangement of sluice-valves is such that water can be admitted to any or all of the compartments as desirable. The dock having been sunk to a sufficient depth to pass under the keel of the vessel, the inlet valves are closed, the vessel drawn over the dock and securely shored up on both sides. The pumps are then set to work, and the compartments emptied until the vessel is completely lifted out of the water. Much care and judgment has to be exercised in these apparently simple operations. The pumps employed are of the centrifugal type, having 8-in. delivery and suction pipes. The discs or fans are made of gun metal, and are placed horizontally, so that the spindles are vertical and pass directly up the side of the dock to the engines on the platform. These spindles are gun metal, 3 in. in diameter, and are coupled to the engine shafts by gun-metal muff-couplings. The weight of the discs and spindles is carried by a thrust-bearing arranged in a bridge-piece above the pump; the wearing surfaces of this thrust-bearing are gun metal and hard wood (lignum vitæ), these substances having been found to wear well when working under water, and to require no lubrication beyond the water itself. The suction pipes of the pumps are each provided with an 8-in. sluice-valve, and the ends are bell mouthed and turned down into a small gun-metal sumph, 15 in. square, let into the bottom of the dock, so that if it be required to examine the dock itself the pumps will drain it perfectly. The delivery pipes, in addition to having a sluice valve, are provided with a self-acting retaining valve on the outside of the dock at the point where the water is delivered. In addition to the 8-in. sluice valve just mentioned, there are four 10-in. sluice valves to each group of three pumps, by means of these the admission and withdrawal of the water to or from the various compartments is regulated. There are, therefore, thirty sluice valves and six inlet valves in the dock; the spindles of all these valves are carried up through the dock to the platform above. Float-rods are provided by which the height of the water in the various compartments can be ascertained. The engines are specially designed

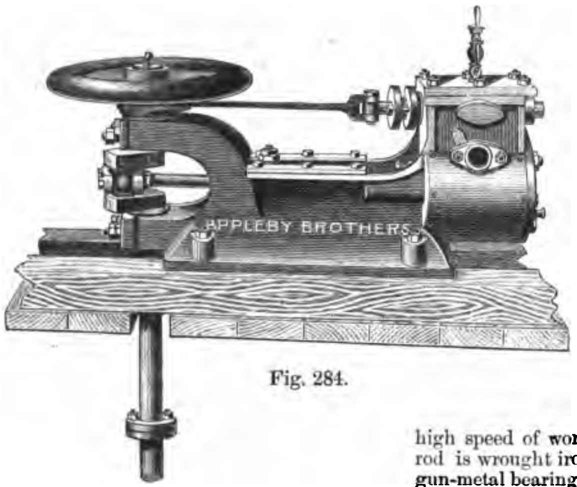

Fig. 284.

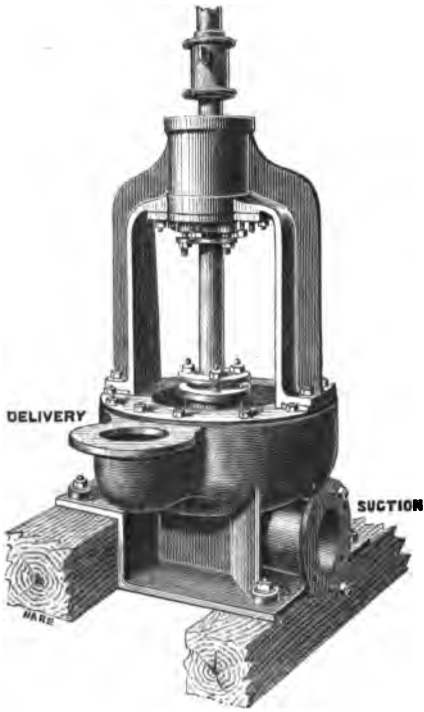

Fig. 285.

to suit the position they occupy and the high speed (about 350 revolutions per minute) they have to run. The cylinder, valve-box, base-plate, guides, and crank bearings are all in one casting. The piston and rod are steel, the former is furnished with rings and springs. The cross-head and guide-block are in one phosphor-bronze casting, and all the bearing surfaces are very large in order to withstand the wear due to the high speed of working. The connecting-rod is wrought iron, fitted with adjustable gun-metal bearings at each end. The slide valve is cast iron and its spindle steel, with gun-metal nuts and glands, &c. The slide valve eccentric is cast iron cast to the fly-wheel, the latter has a circular rim so that the attendant can easily pull the crank round a quarter of a turn if the engine should stop on the dead centre. The eccentric straps are gun metal and the rod wrought iron. The crank-shaft is made of cast steel, 2½ in. in diameter, and has a slotted crank; it runs in two adjustable gun-metal bearings of ample length. The cost of such a plant of machinery, with a 30 horse-power semi-portable boiler, and steam and exhaust pipes for all the engines, is £2,250. One or two cranes on the side of the dock are a very valuable addition. Prices and particulars of hand or steam cranes will be found in Section 2.

IRON FLOATING DOCKS.—Although timber was admirably adapted for the conditions to be fulfilled by the dock last described, as is well known, a large number of floating docks have been constructed entirely of iron, and in many situations the greater strength and durability obtained will more than compensate for the larger outlay of capital required for iron structures.

The Spanish Government have an iron floating dock at Carthagena, and another at Ferrol, similar in shape to that illustrated by Fig. 283, but of much larger proportions. The length of the dock at Carthagena is 320 feet, and the breadth 105 feet; the total weight including the machinery is about 4,500 tons It is capable of lifting a vessel of 6,500 tons, and has been used for raising and docking the Spanish ironclad "Numancia," which weighs more than 5,600 tons.

The floating dock at Ferrol is still larger, the dimensions being 350 feet long, 105 feet broad, and the total weight is 5,000 tons; this dock will take a vessel of 8,000 tons.

As it sometimes happens that two or three ships require slight repairs at the same time, it would be inconvenient if one ship occupied the whole of the dock during the time required for the repairs; this difficulty is met by making a shallow basin with a number of "slips" or inclined planes around it. The dock having raised the ship in deep water is towed into the shallow basin, fixed opposite to an unoccupied slip, and the ship is hauled up by the chains attached to cradles on which the ship is secured.

CLARK'S HYDRAULIC LIFT GRAVING DOCK. Excellent examples of these may be seen at the Victoria Docks, London, where they have been in successful operation for several years; also at Malta, and many other places.

SCOOP WHEELS. The Upwell, Outwell, Denver, and Welney district, which form a portion of the "Fen country" in Norfolk, has for many years past been drained by scoop wheels driven by windmills; but as, has already been observed, the results obtained from this kind of motor are not sufficiently reliable, and the Commissioners eventually decided to have a new pumping station and scoop wheel driven by steam power. The conditions to be fulfilled were stated in a specification issued by the Commissioners, and the design prepared by the Author's firm, and illustrated by Fig. 286, was accepted, and has been successfully carried out.

Direct experiment has shown that some of the scoop wheels now at work do not realize a useful effect of more than 25 per cent. of the power expended, but several important improvements have been introduced in the machinery at Upwell. The wheel is capable of delivering 3,500 cubic feet of water a minute to a height of 4 ft., or a proportionately smaller quantity to a greater height; it is constructed as far as possible of wrought iron, and is 24 ft. in diameter, by 4 ft. wide. The blades are curved in such a manner as to leave the water easily; in many wheels merely straight boards are used, which lift the water considerably higher than is necessary; the curved blades are 10 ft. long, and are shrouded by wrought-iron plates on both sides, the shroudings being carried into the centre. An adjustable curved sluice or (as they are sometimes termed) shuttle is provided on the drain or inlet side of the wheel; by this means the volume of water admitted to the wheel is regulated, and is also directed on the blades in such a manner as to prevent any shock from impact. The walls of the culvert in which the scoop wheel works are curved in to the width of the wheel on both the inlet and outlet side, so that the water runs into and out of the wheel at as nearly as possible the average speed of the blades; this reduces friction and conduces to steadiness in working. The sill over which the water is delivered is gently curved to prevent any unnecessary loss of power. The wheel is hung true, and keyed on to a turned wrought-iron shaft, about 9 in. diameter, and this runs in massive pedestals fitted with adjustable gun-metal bearings. To one side of the scoop wheel is bolted a geared wheel made in segments, about 20 ft. diameter, and into this works a pinion on the engine crank-shaft. The engines are of the horizontal high pressure compound condensing type. The high pressure cylinder is 10 in. diameter and 20 in. stroke; it is fitted with a Meyer's expansion gear which is capable of adjustment whilst the engine is running, and by means of which the weight of steam consumed can be adjusted exactly to the weight of water and the height through which it has to be raised. The pipe leading the exhaust steam from the high pressure to the low pressure cylinder is made of a very large diameter to act as an intermediate receiver. The low pressure cylinder is arranged and proportioned in such a manner that high pressure steam direct from the boiler can be admitted to it if necessary. The air-pump is in the centre of the condenser chamber, and is placed directly behind the low pressure cylinder on the same bed-plate, the steam and air-pump pistons being coupled to the same rod. The connecting-rods are made of best hammered scrap iron, with adjustable gun-metal bearings at both ends, and are 50 in. (2½ times the stroke) from centre to centre. There is a feed pump driven from the cross-head of the high pressure engine, but in addition to this a donkey pump is provided for feeding the boilers. The steam pipes and cylinders are all felted and lagged, the high pressure cylinder steam jacketed, and every precaution is taken to prevent waste of fuel. The crank shaft is of wrought-hammered scrap iron, and carries a heavy fly-wheel. The steam for the engines is generated in two Cornish boilers, the internal flues being fitted up with galloway tubes; the chimney is in brickwork about 60 ft. high. The boiler mountings are of the kind used in the best class of work, and include double safety-valves, pressure water-gauges, fusible plugs, &c., and were tested to a pressure of 160 lbs. per square inch, the working pressure being 80. This plant of machinery is compact, the engine and boiler houses are side by side, the middle wall being common to both; whilst the scoop wheel, although outside the engine-house, is protected by a neat wooden casing. A coal store is built close to the station, capable of holding about 60 tons of coals. The quantity of water and the height to which it has to be lifted varies so much that special designs and estimates are required for each individual district. The cost of the whole of this machinery is £1,700, and the weight is 45 tons. The cost of the buildings, including chimney, coal store, casing to scoop wheel, and all foundations, was £700, but this item will vary materially according to the locality, nature of foundation required, &c.

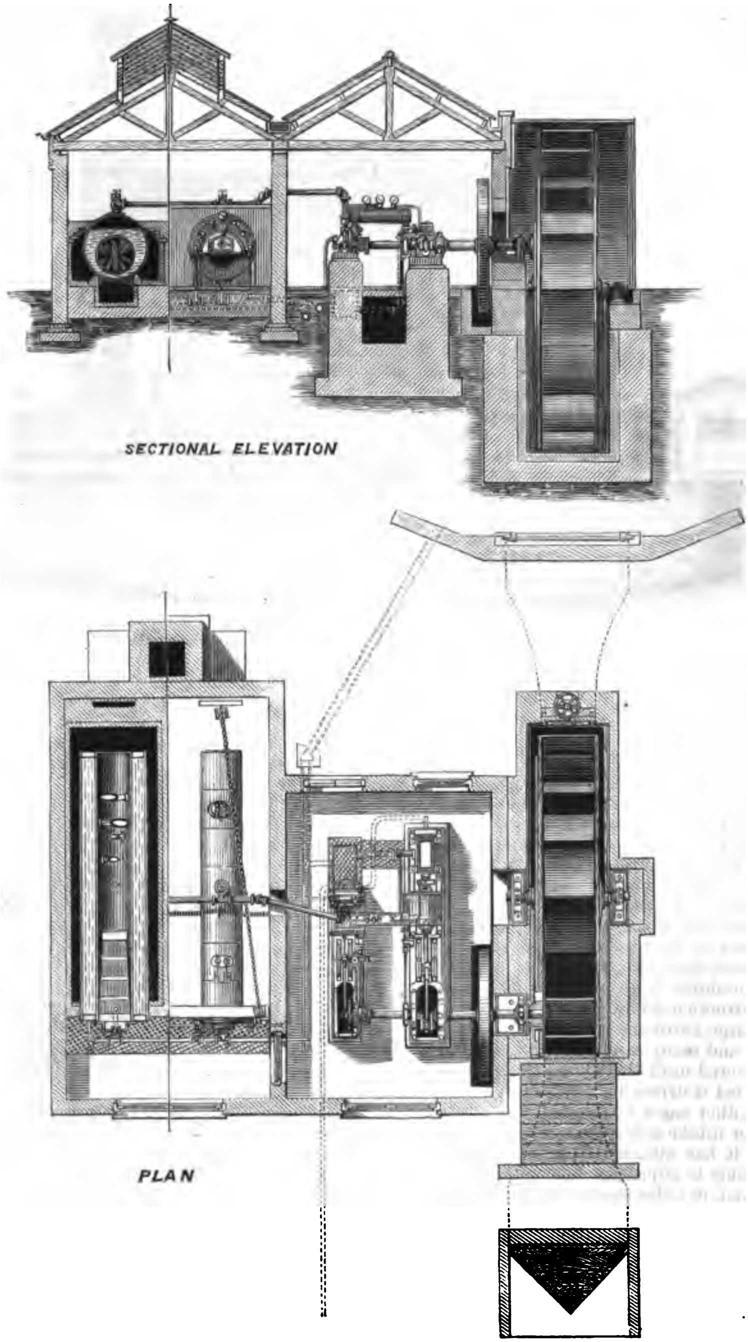

Fig. 286.

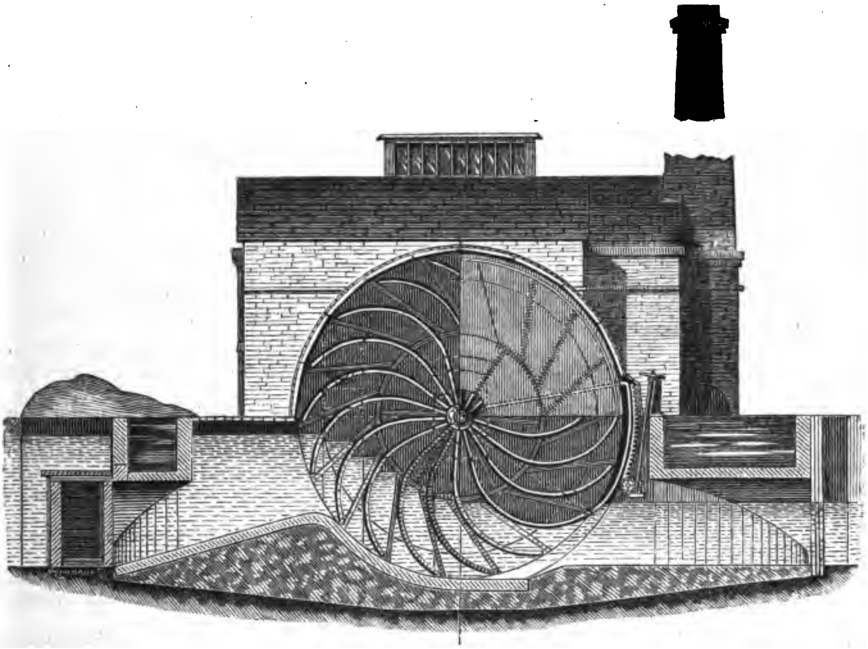

Fig. 286.*

It is somewhat remarkable that although a large proportion of the Fen country in England, and immense districts in Holland, depend upon scoop wheels for their very existence, but little scientific research has been devoted to improvements in the construction of the wheels and the works connected with them. This may probably, in a great measure, be due to the fact that hitherto windmills have for the most part been the motors employed, and that waste of power has not been so prominently noticeable as it must be when a heavy coal bill has to be paid. Now, however, the use of steam power is greatly increasing, and it becomes necessary to obtain the highest useful effect from the power employed.

The blades of most wheels have hitherto been straight, pointing towards the centre, or tangental to a small circle. In some wheels of more modern design curved blades have been used, but sufficient care is rarely taken to prevent the shock caused by the too sudden impact of the water on the intake, or what may be called the "suction" side, nor has sufficient allowance been made for a free flow on the opposite or delivery side. The wheel races are often formed with shoulders, or are suddenly contracted; it is scarcely necessary to point out that these errors in construction are in direct violation of the laws which govern the flow of liquids. In some cases large clearance spaces, varying from 1 inch to 3 inches, are allowed on each side of the wheel, and many examples may be seen where the clearance is so great that absolutely no water is delivered until the wheel attains a considerable speed. This is specially observable when the wheel is driven by a windmill running with a light or fitful breeze.

In other cases no provision is made for shutting off or directing the flow of water on the drain or intake side; the absence of this regulating power throws the whole work on the wheel before it has attained sufficient momentum, and there is the further disadvantage that it is impossible to adjust the flow of water on the intake side to the height to which it should be delivered, in order to equalise the work and obtain the maximum duty from the power employed. This is a very serious disadvantage when the water raised is discharged into a tidal river, as it often involves the cessation of work during a portion of each tide.

From the foregoing remarks it will be seen that although the scoop wheel will probably never give very high results in economy of power, it requires less attention than almost any other kind of machinery usually employed for raising water, and may be relied on to deal with the sudden increase due to floods, even after it has been standing for a long period; these are important advantages, and may sometimes outweigh the disadvantages in economy of power to which reference has been made.

In addition to the arrangements of machinery already described as having been successfully employed for the reclamation and drainage of low lands, mention should be made of the very ingenious apparatus designed by the late Sir W. Fairbairn for raising water on low lifts. This apparatus consisted of a wrought-iron trough, about 25 feet long by 30 feet wide, with sides and one end closed; the open end was fitted with a pair of trunnions, having their bearing on the embankment wall of the canal into which the water had to be discharged, the low-water canal being parallel to the high level, directly below the trough. At the closed end there were valves of large area opening upwards in the bottom of the trough, and this end was fitted with trunnions, to which were attached a pair of connecting-rods from the beam of an ordinary single-acting Cornish engine.

The reciprocations of the beam of the steam-engine were communicated by the connecting-rods to the closed end of the trough or scoop, causing it to dip this end into the low-level drain, the valves above referred to at the same time allowing the water to rush into it until the water level in the trough became the same as that outside. At the upward stroke of the engine beam the valves closed, this end of the trough was raised, and the water was discharged over the embankment.

A trough of these dimensions was capable of lifting 17 tons of water per stroke with an engine power of 60 horse, and the duty in water lifted was equal to about 3 lbs. of coal per horse power

It will, perhaps, be useful here to record some data as to the engine power required for a given area of land.

Littleport Fen, near Ely, containing 28,000 acres, was drained by engines of 30 and 40 horse-power, and these two engines did the same work and with more certainty than it was previously done by upwards of 70 windmills; the cost of maintaining such a number of mills in working order far exceeded the outlay for fuel for the engines.

Deeping Fen, Lincolnshire, has an area of 25,000 acres, and is drained by two engines of 60 and 80 horse-power.

Middle Fen, Cambridgeshire, having an area of 7,000 acres, is drained by an engine of 60 horse-power; and many other examples could be given showing about the same average results.

The rainfall over these districts has been ascertained to average about 26 inches per year. Allowing for evaporation and absorption, about 18 cubic feet of water per superficial yard of ground is the quantity required to be lifted per annum; and assuming that the lift does not exceed 10 feet (this figure being in excess of that usual in this country), the best authorities on this subject agree that for moderate areas to be drained, 10 horse-power should be provided for each 1,000 acres, and an engine of this power working twelve hours per day will do the work in about 140 working days per annum.

Most of the high-level canals are below high water at the points at which they discharge into the sea, and they are protected by self-acting sluices, whereby the water is discharged at the ebb tide, and as the tide flows the sluice gates close, thus preventing the sea from backing up the water in the canals or drains. A quantity of land in close proximity to the sluice may thus be drained by gravitation, and some of these works are of a most extensive character, notably that carried out by the late Mr. Rennie, in 1821, for the drainage of the Ouse and Nene, whereby 300,000 acres were completely drained, and the low water lines of the rivers reduced several feet. Also, that carried out by Messrs. Telford and Rennie, in 1829, at the outfall of the Nene, commencing near Wisbeach and terminating at the Wash. This improvement had the effect of lowering the water mark in the river 10 to 11 feet, and bringing 100,000 acres of land into cultivation that were formerly a stagnant marsh.

In some cases syphons have been introduced for the purpose of carrying the water from the canals into the outfalls; and on the occasion of the blowing up of the outfall sluices of the Middle Level at Lynn, Sir John Hawkshaw had recourse to this system. The syphons performed the work during the reconstruction of the new sluice in a very satisfactory manner. The new sluice was opened in the year 1877.

In designing pumping stations either for drainage or irrigation it is often necessary very carefully to consider the nature of the strata on which the foundations have to be made, and an error in judgment on this important subject often leads to endless trouble and expense.

Many instances of this may be seen, but a reference to only one will suffice. This is a pumping station where high economy in consumption of fuel, &c., was expected, and no expense was spared either as regards machinery, foundations, or buildings. Beam-engines of the type Fig. 1 are used; these are very economical if they can be run at a proper speed, but it would be almost impossible to make foundations in that ground to stand the strains which have to be carried on a small area; the consequence is the engines cannot run at a speed consistent with economical working, and the repairs are exceptionally heavy. If vertical or horizontal compound and condensing engines had been used the strains would have been entirely different, and, being distributed over a large area, the working results would be in every sense more satisfactory.

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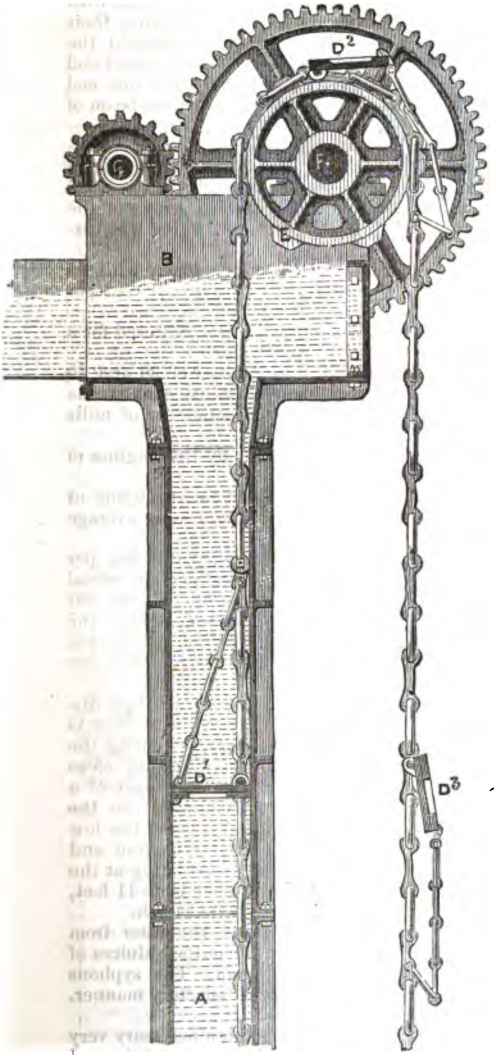

Fig. 287.

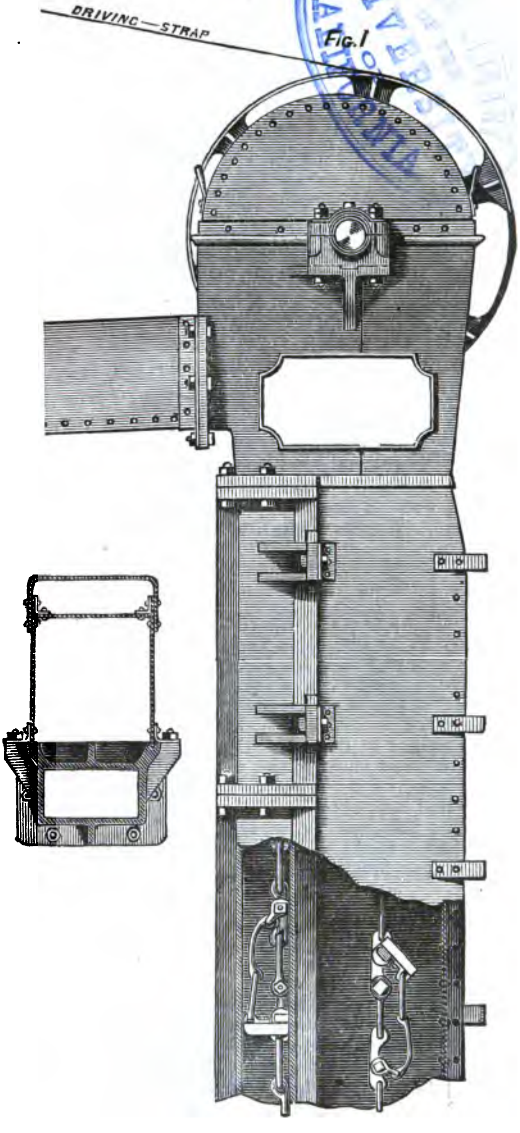

Fig. 288.

MURRAY'S CHAIN PUMPS. Fig. 287 shows an open back chain-pump. These pumps are extremely simple in construction, and are well adapted for contractors' use in the formation of docks, tunnels, coffer dams, or for sewage works, drainage, irrigation, &c. The absence of clacks, valves, or any kind of packing is most advantageous, as however highly charged the water may be, with sand, mud, weeds, sewage, or other foreign matter, it is impossible to choke the pump. If any foreign substance gets between the lift and the barrel, a partial back turn of the chain immediately releases it, the lift folding up, and allowing the obstruction to be carried up in the stream. For Numbers 1 to 5, 2 ft., and in larger sizes, 3 ft. should be allowed beyond the actual height required.

The pumps are measured from the ground to the bottom of the delivery trough, and it is essential that these dimensions should be stated. The working parts of the chains and lifts are steeled in both the larger and smaller sizes. These pumps are usually driven by a portable engine, or by a steam crane, or pile driver; but where they are required for permanent use, such as at sewage works, horizontal or vertical fixed engines may be advantageously employed. See Section 1.

PRICES OF MURRAY'S OPEN BACK CHAIN PUMPS, Fig. 287.

Single chains (geared heads extra for pumps under 40 feet high).

Size number	1	2	3	4	5
Size of pump in inches	8×4	10×5	12×6	14×7	16×8
Number of gallons pumped per minute ..	500	700	1000	1300	1600
Nominal horse-power for 10 ft. lift ..	1½	2	3	4	5
Price of pump complete, 10 ft. high ..	£36 0	£45 0	£55 0	£64 0	£72 0
Price extra for each additional ft.	£2 8	£3 0	£3 12	£4 4	£4 16

Double chains, with geared heads.

Size number	6	7	8	9	10
Size of pump in inches	24×8	27×9	30×10	33×11	36×12
Number of gallons pumped per minute ..	2000	2500	3000	3500	4000
Nominal horse-power for 10 ft. lift ..	6	7½	9	10½	12
Price of pump complete, 10 ft. high ..	£96 0	£108 0	£120 0	£132 0	£144 0
Price extra for each additional ft.	£5 8	£6 0	£6 10	£6 18	£7 4

Packing for shipment, 3 per cent.

MURRAY'S COMPOSITE CHAIN PUMP, Fig. 288, having back barrel, is perfectly dry to work under. The working barrel is made up of castings in 5 ft. length, bolted together with flanged joints; the back barrel is of wrought iron, and is one-fifth larger than the cast-iron uptake or working barrel, consequently there is no danger of the lifts fouling as they descend. Any length of the back barrel can be taken off and replaced in a few minutes, and a ladder is fitted, if desired, as shown in the engraving. The construction of the working parts is similar to that shown on the preceding page, and solid matter in the water may be lifted without choking the pumps. In ordering these pumps it is necessary to give the height to which it is desired to lift the water, and to allow 2 ft. extra in the smaller sizes up to No. 5, and 3 ft. extra in larger sizes.

The cast-iron working barrels can be packed inside the wrought-iron back barrels, which saves measurement for freight, and reduces the risk of the flanges of the working barrel being broken in transit.

PRICES OF MURRAY'S CLOSED BACK CHAIN PUMPS, Fig. 288.

Single chains (geared heads extra for pumps under 40 feet high).

Size number	1	2	3	4	5
Size of pump in inches	8 × 4	10 × 5	12 × 6	14 × 7	16 × 8
Number of gallons pumped per minute	500	700	1000	1300	1600
Nominal horse-power for 10 feet lift ..	1½	2	3	4	5
Price of pump complete 10 feet high ..	£40 0	£53 0 0	£65 0	£78 0 0	£90 0
Price extra for each additional foot ..	£2 15	£3 7 6	£4 5	£4 16 6	£5 10

Double chains with geared heads.

Size number	6	7	8	9	10
Size of pump in inches	24 × 8	27 × 9	30 × 10	33 × 11	36 × 12
Number of gallons pumped per minute	2000	2500	3000	3500	4000
Nominal horse-power for 10 feet lift ..	6	7½	9	10½	12
Price of pump complete 10 feet high ..	£135 0	£150 0	£168 0	£180 0	£197 0
Price extra for each additional foot ..	£7 12	£8 5	£9 13	£10 10	£11 11

Packing for shipment about 3 per cent.

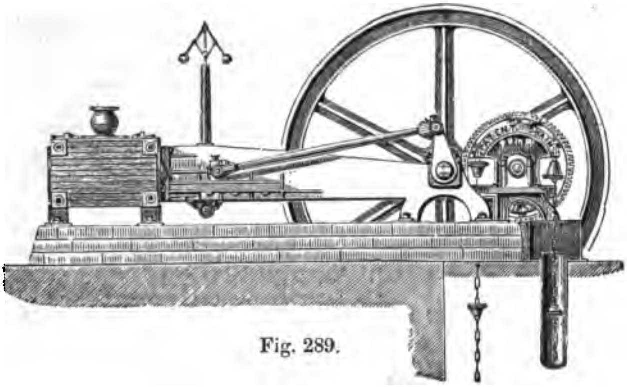

Fig. 289.

BASTIER'S CHAIN PUMP, Fig. 289, is adapted for drainage, irrigation, pumping sewage, &c., and is so simple that very little explanation is required beyond what is furnished by the illustration. It is suitable for deep vertical lifts, is inexpensive, and the cost of maintaining it is very small. A contracted part or working barrel is inserted at intervals; this is rather smaller in diameter than the main-pipe, and one of these working barrels is always placed at the lower end. An endless chain works over the driving-wheel at the top, going down freely and coming up through the tube, into which it is guided by a bell-shaped mouthpiece; the india-rubber discs or buckets fixed on the chain are smaller in diameter than the main-pipe, but fitting tightly in the working barrels, so that all the water entering is forced up through the rising main-pipe. The disc being clear all round from the pipe for nine-tenths of the whole distance, the friction is reduced to a minimum, and the power required is consequently smaller than is required for working ordinary chain-pumps.

The prices and particulars of either horizontal or vertical boilers and engines suitable for driving these pumps will be found in Section 1. The cost of a pump complete for any depth may be ascertained by adding the cost of the pipes, chains, &c., the prices for which are given at per yard, to the price of the pump gear. Thus, the cost of an 8-inch pump, for 40 yards deep is 40 × £4 = £160 + £45 = £205.

PRICES OF DISC CHAIN PUMPS, Fig. 289.

Diameter of pump in inches..	2½	3½	4	5	6
Maximum number of gallons per minute ..	25	80	120	200	300
Price of pump gear for 10 yards lift ..	£8 10	£17 0	£22 0	£24 0	£33 0
„ pipes, chains, and discs, per yard lift	£1 5	£1 12	£1 18	£2 11	£3 4
„ pump gear for 50 yards lift ..	£12 0	£22 0	£26 0	£27 0	£36 0
„ pipes, chains, and discs, per yard lift	£1 6	£1 14	£2 0	£2 13	£3 6
„ pump gear for 100 yards lift ..	..	..	£30 0	£30 0	£40 0
„ pipes, chains, and discs, per yard lift	..	..	£2 2	£2 15	£3 8
„ pump gear for 150 yards lift ..	..	..	..	£35 0	£45 0
„ pipes, chains, and discs, per yard lift	..	..	..	£2 15	£3 10

Diameter of pump in inches..	8	9	10	11	12
Maximum number of gallons per minute ..	500	600	800	1000	1200
Price of pump gear for 10 yards lift ..	£40 0	£50 0	£60 0	£70 0	£80 0
„ pipes, chains, and discs, per yard lift	£3 17	£4 12	£5 11	£6 13	£7 18
„ pump gear for 50 yards lift ..	£45 0	£57 0	£70 0	£80 0	£90 0
„ pipes, chains, and discs, per yard lift	£4 0	£4 15	£5 14	£6 14	£8 2
„ pump gear for 100 yards lift ..	£50 0	£65 0	£80 0	£90 0	£100 0
„ pipes, chains, and discs, per yard lift	£4 2	£4 19	£5 17	£6 18	£8 4
„ pump gear for 150 yards lift ..	£60 0	£72 0	£90 0	£100 0	£120 0
„ pipes, chains, and discs, per yard lift	£4 5	£5 4	£6 2	£7 1	£8 6
„ pump gear for 200 yards lift ..	£70 0	£80 0	£100 0	£120 0	£150 0
„ pipes, chains, and discs, per yard lift	£4 7	£5 6	£6 4	£7 4	£8 10

Packing for shipment, about 3 per cent.

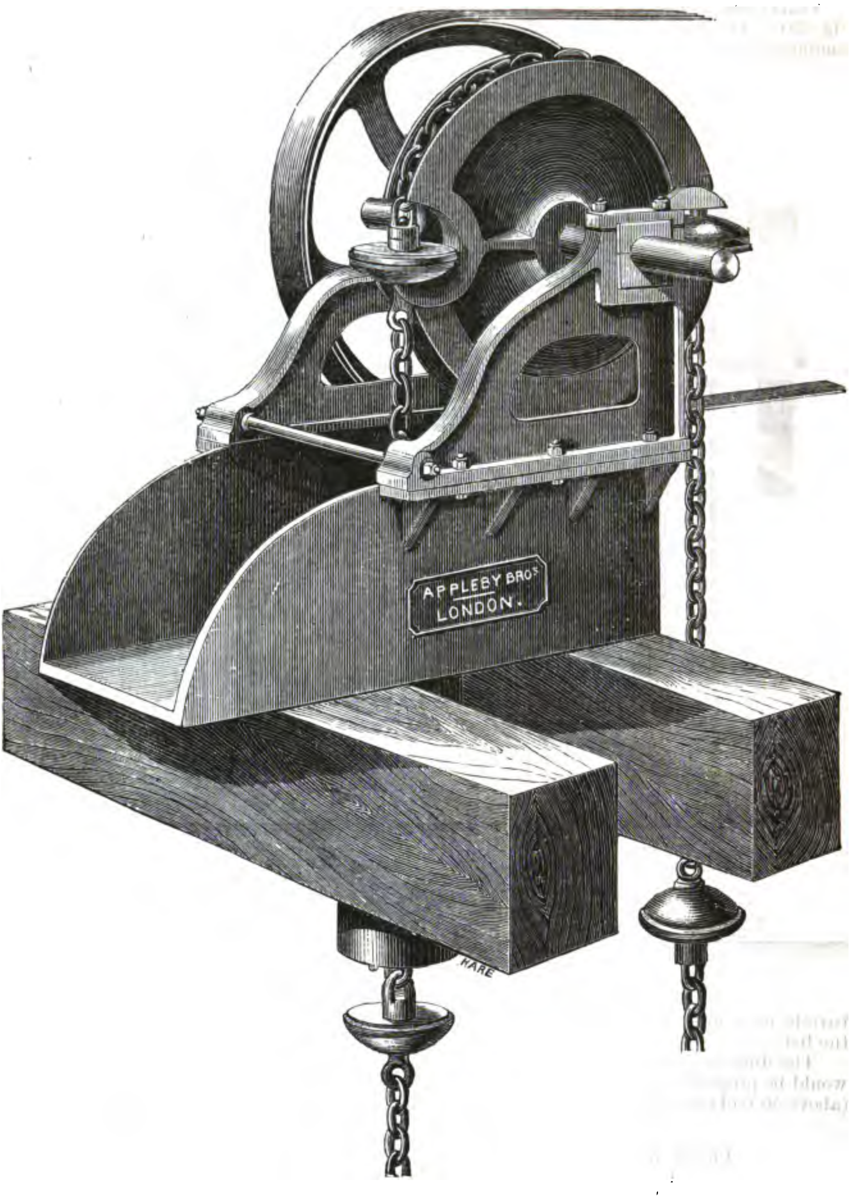

Fig. 290.

CHAIN PUMP DRIVEN BY STRAP, Fig. 290. The cast-iron flanged rising main of the pump is bolted up to a strong cistern casting a delivery trough; on this casting are bolted a pair of side-frames carrying the chain-wheel, and driving pulleys; the wrought-iron shaft on which these wheels are keyed runs in adjustable gun-metal bearings. The whole forms a very neat arrangement. For prices, see preceding page.

VERTICAL DOUBLE-ACTING LIFT AND FORCE PUMP DRIVEN BY BELT OR GEAR, Fig. 291. This class of pump is especially adapted for use in factories or railway stations for pumping hot or cold liquids, or it may be used as a fixed fire engine.

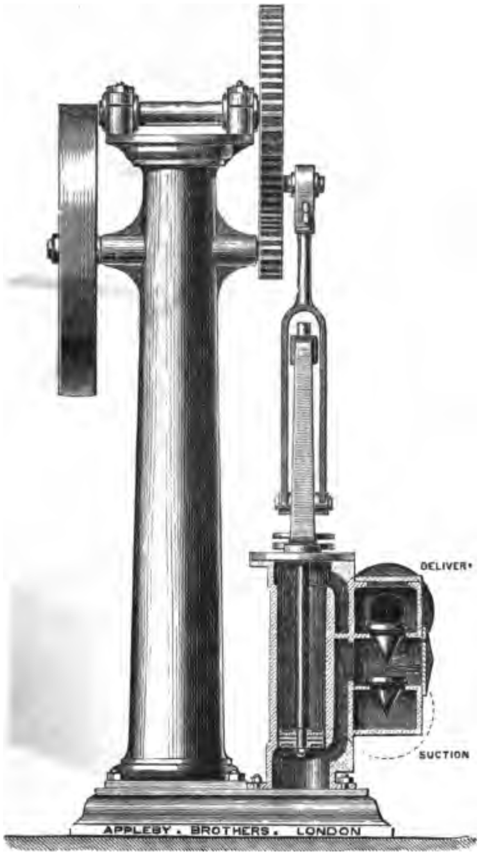

Fig. 291

The construction and working of the pump is clearly shown in the section. The pump illustrated was fitted with Appleby's patent conical valves, but any other valve can be used, such as grids with guards and india-rubber discs or leather clacks. Covers are provided to enable the valves to be easily examined. The piston is formed by plates, between which are double cup leathers, and the piston rod is guided by a bridge bushed with gun metal. The pump is fitted with a wrought-iron fork connecting-rod with adjustable gun-metal bearings at the crank pin end, of the form known as the marine pattern, which are generally preferred to the strap and cotter shown in the engraving.

The teeth of the gear driving the pump are carefully shaped and proportioned, in order to absorb as little power as possible in friction, and make no unnecessary noise. The wheel is keyed on to a wrought-iron shaft running in two plummer blocks fitted with adjustable gun-metal bearings, loose caps, &c.

The pinion is keyed on to a wrought-iron shaft running in long bosses cast on the main column; on the other end of this shaft is keyed the strap pulley. In the engraving only one pulley is shown, and in some cases this is sufficient, but it is often found convenient to have both a fast and loose pulley, in order that the pump may be started and stopped without stopping the shaft or engine from which it is driven.

The pump is mounted on a massive cast-iron bed-plate, carrying a hollow cast-iron column, which can be utilized as an air-vessel if required, and the whole being independent of support from the top or side can be firmly bolted down to the ground or floor and driven by steam or any other motive power. The pumps are usually made with cast-iron barrels of a fine quality of grey iron, but the extra cost of gun-metal lining is given in the list.

The duty in gallons per hour is calculated for 40 strokes of the pump per minute, and would be proportionately more or less if the speed were increased or decreased. For high lifts (above 50 feet) the pumps should be driven at a lower speed than 40 strokes per minute.

PRICES, &c., OF VERTICAL DOUBLE-ACTING COLUMN PUMPS, Fig. 291.

Diameter of pump in inches	3	4	5	6	8
Length of stroke in inches	12	12	12	12	14
Number of gallons per hour	1200	2500	3300	5800	11,500
Price of pump with iron barrel	£32	£35	£41	£45	£60
„ „ brass lining	£35	£40	£46	£52	£70

Packing for shipment about 4 per cent.

TWO VERTICAL DOUBLE-ACTING LIFT AND FORCE PUMPS, Fig. 292. These are mounted on one base-plate, carrying a hollow column between the pumps. The general construction is in every respect similar to that shown and described on the preceding page, and the remarks made with regard to that pump apply equally to these. Double gear is employed to equalize the strain on the shafts.

The number of gallons in the list is calculated with the pumps running at 40 strokes per minute.

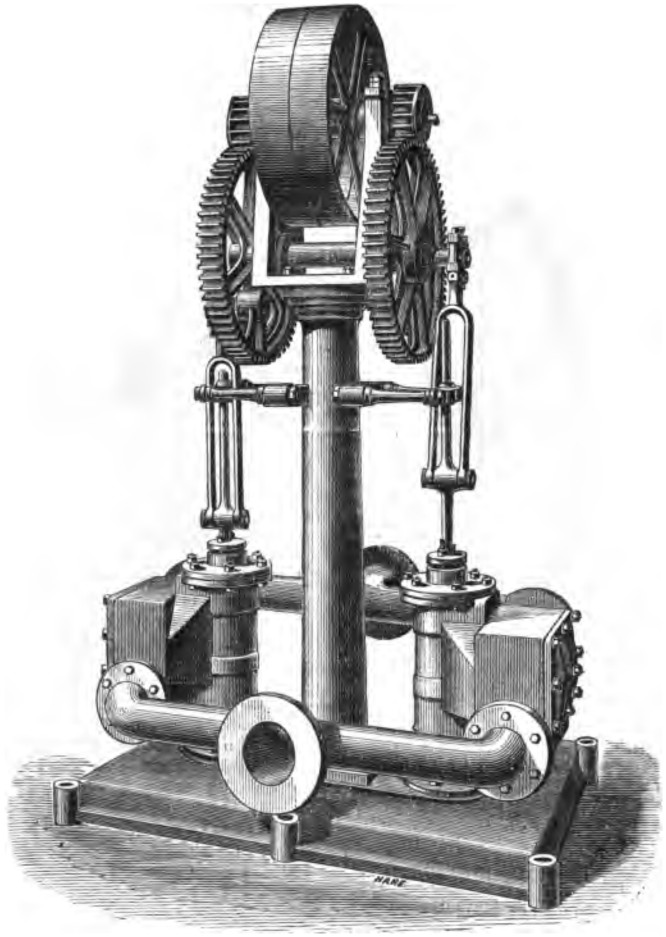

Fig. 292.

Prices of Pairs of Vertical Column Pumps, Fig. 292.

Diameter of pumps in inches	3	4	5	6	8
Length of stroke in inches	12	12	12	12	14
Number of gallons per hour	2400	5000	6600	11,600	23,000
Price of pump with iron barrels ..	£47	£52	£66	£73	£95
„ „ brass lining ..	£53	£62	£76	£85	£110

Packing for shipment, 4 per cent.

DOUBLE-ACTING PUMPS FOR HAND OR STEAM POWER, Fig. 293. This arrangement is compact, and was designed for use on a ship's deck; the gearing is dispensed with and the crank shaft has two chain wheels and a heavy fly-wheel keyed on it; the chain wheels can, however, be replaced by strap pulleys if desired. The connecting-rods of the column pumps are done away with and sliding blocks and slotted cross-heads substituted, the piston rods being guided above the crank shaft. This construction absorbs rather more power in friction than that shown in Fig. 292; but the whole machine is reduced in height, and this permits it to be used in situations where it would be impossible to adopt a column pump. The crank shaft is turned down at both ends, and handles may be fitted to it as shown by the dotted lines in the engraving.

These pumps are exceedingly simple in action, and all the working parts are easily accessible. They are usually fitted with gridiron valve seats and india-rubber disc valves, so arranged that by removing one bolt, the valve, guard, and grid can be taken out; and if the valve be worn out a new one can be substituted and the whole replaced in a few minutes. The piston packings are double-cupped leathers or india-rubber specially prepared for the purpose, so that the pumps may be used for any chemical which does not affect these substances. Their working is rarely interrupted by great or sudden variations in temperature, and they can be immediately set to work after having remained unused for long periods of time either in hot or cold climates. Being double-acting, that is to say, capable of lifting and forcing water on both the up and down stroke, they are equal in capacity to two single-acting pumps of equal diameter. The proportions throughout are such that they are applicable to all ordinary purposes, and in an emergency they can be employed as fire-engines or ships' pumps of the most powerful description.

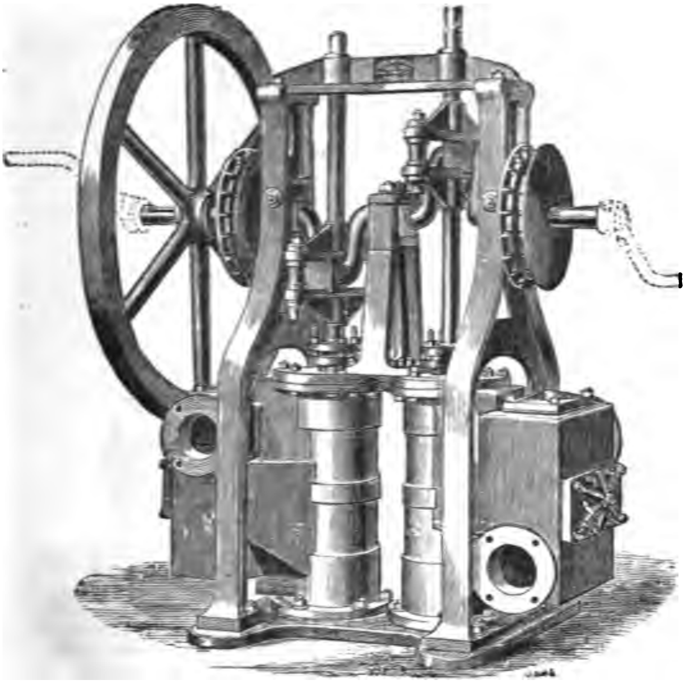

Fig. 293.

The barrels are made entirely of hard grey cast iron or bushed with gun metal, and the cost of both forms is given. Air vessels can be provided at an extra cost of from £3 to £8. For pipes, &c., suitable for use in conjunction with these pumps, see pages 148 to 154; and for firecocks, unions, hose, nozzles, &c., see pages 142 to 153.

The number of gallons delivered per hour given in the following list is calculated for the pumps running at 40 strokes per minute.

PRICES OF DOUBLE-ACTING VERTICAL PUMPS, Fig. 293.

Diameter of pumps in inches	3	4	5	6	8
Length of stroke in inches	12	12	12	12	14
Number of gallons per hour	2400	5000	6600	11,600	23,000
Price with cast-iron pumps	£42	£47	£59	£67	£85
„ brass-lined pumps	£48	£57	£69	£79	£100

Packing for shipment, 4 per cent.

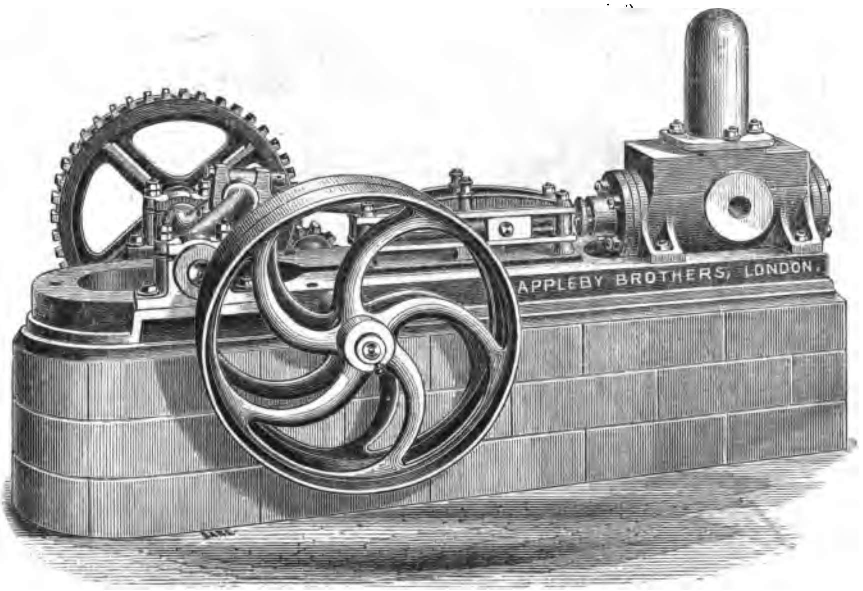
APPLEBY BROTHERS, LONDON.

Fig. 294.

HORIZONTAL DOUBLE-ACTING PUMP, Fig. 294. This neat and compact form of pump occupies rather more ground area but much less height than a column pump of equal capacity. The barrel, although placed horizontally instead of vertically, is very similar in proportions and general construction to that of the column pump, Fig. 292. Feet are cast on the pump for bolting to the bed-plate, and the arrangement of the valves is modified to suit the altered position of the barrel. The valves may be of any of the kinds referred to in the preceding pages according to the purpose for which the pump is required. An air vessel is bolted on the top of the barrel, which tends to relieve the pump from shocks and to equalize the speed of the water in the delivery pipe; it also serves as the valve box cover, and can be easily removed if the valves have to be examined. The pistons are packed with double-cupped leather or specially prepared india-rubber packing, and the piston rod is guided by double cast-iron blocks working between planed guide bars bolted down to the bed-plate. The connecting-rods are wrought iron fitted with adjustable gun-metal bearings at both ends. The crank-shaft is wrought bent so as to retain the whole strength of the bar (the grain being continuous) and runs in two plummer blocks fitted with adjustable gun-metal bearings, loose caps, bolts, nuts, &c. The teeth of the wheel and pinion are carefully shaped and proportioned, in order to absorb as little power as possible in friction and to make no unnecessary noise. The pinion shaft is carried in bosses cast on the bed-plate, and on this shaft are the fast and loose strap pulleys. The whole may be mounted on masonry or brickwork so as to raise the pulleys clear of the ground, or a small pit may be dug in the ground to clear the driving straps.

The number of gallons delivered per hour given in the list is calculated for 40 strokes per minute of the pumps.

PRICES OF HORIZONTAL DOUBLE-ACTING PUMPS, Fig. 294.

Diameter of pump in inches	3	4	5	6	8
Length of stroke in inches	12	12	12	12	14
Number of gallons delivered per hour ..	1200	2500	3300	5800	11,500
Price with cast-iron pump..	£35	£40	£45	£50	£65
„ brass-lined pump	£38	£45	£50	£57	£75

Packing for shipment, 4 per cent.

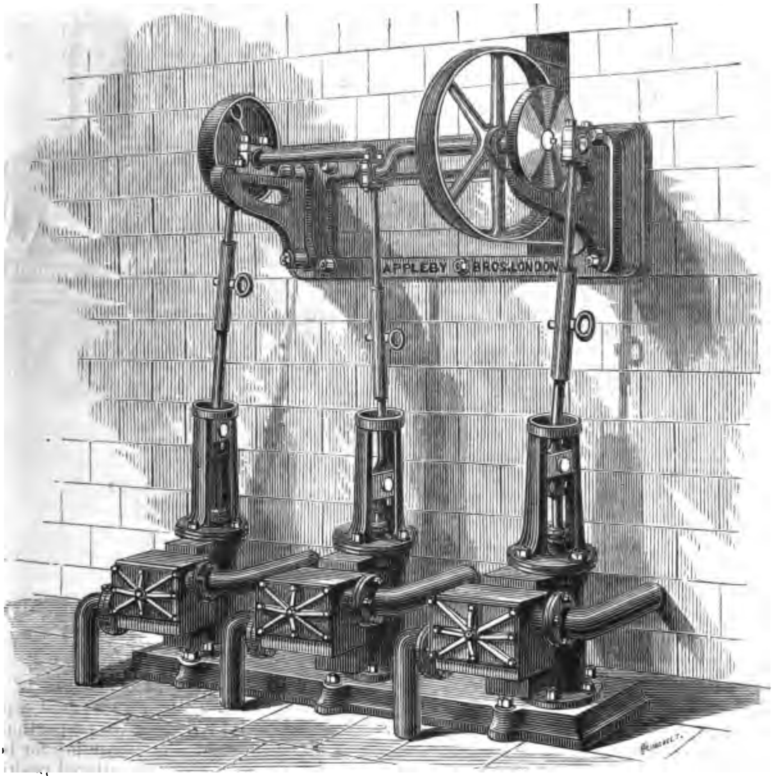

Fig. 295.

SET OF THREE DOUBLE-ACTING PUMPS, Fig. 295. This arrangement of double-acting pumps is specially adapted for employment at gasworks. One of the three pumps raises water, the second tar, and the third ammoniacal liquor. They are made of any metal desired, but usually of cast iron, and the prices given are for that metal. The suction and delivery pipe may be taken in any desired direction.

The pumps are placed near to a wall, and are driven from a wrought-iron crank shaft directly over them. The crank is formed by bending the shaft, so as to preserve the continuity of grain in the metal, and is, therefore, much stronger than if slotted. One of the pumps is driven from a bent crank, and the other two by crank pins in disc plates keyed on ends of crank shaft; the shaft carries also a pulley to be driven by strap. The crank shaft runs in two plummer blocks fitted with adjustable gun-metal bearings, loose caps, &c. These plummer blocks are supported by cast-iron cantilever brackets bolted to the wall. The connecting-rods are wrought iron, bored at the lower end, and fitted at the upper end with adjustable gun-metal bearings of the marine pattern. The piston rod is guided at the upper end by cast-iron bored guides, cast to top cover. The pumps are arranged so that by simply drawing out a cotter, any one of them may be stopped without stopping the others. This is frequently a great convenience. The valves are generally plain cast-iron balls in the tar and ammoniacal liquor pumps, and are arranged in such a manner that they can be easily examined without breaking the joints of either suction or delivery pipes. The cost of flanged pipes suitable for use with these pumps will be found on pages 148 to 154.

The number of gallons delivered per hour is calculated for thirty strokes per minute of the pumps.

Prices of Sets of Three Pumps, Fig. 295.

Diameter of pumps in inches	3	4	5	6	8
Length of stroke in inches	12	12	12	12	14
Number of gallons per hour	900	1850	2450	4300	8600
Price of set of pumps complete	£60	£75	£90	£105	£135
Diameter of suction and delivery pipes in inches	2	2½	3	4	5

Packing for shipment, 4 per cent.

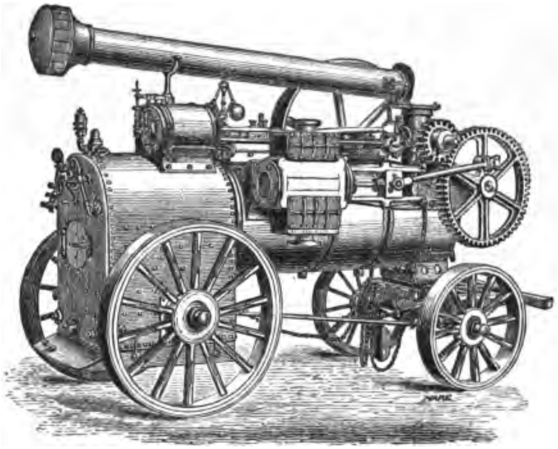

Fig. 296.

PORTABLE STEAM PUMPING-ENGINE, Fig. 296. This form of pumping engine is much used by farmers and others for raising and forcing large quantities of water for sheep-washing, drainage, irrigation, &c. The portable engine is of the usual construction, which is fully described and illustrated in Section 1. The pump is double-acting, and is bolted to a strong cast-iron saddle attached to the side of the boiler. The driving pinion is made to slide out of gear, so that the engine is available for any of the numerous purposes to which an ordinary portable engine can be applied. The pump barrel is usually lined with gun metal, and fitted with gun-metal valve seats and guards and india-rubber disc valves. Covers are provided, by removal of which these valves may be examined.

For prices of pipe suitable for use with these pumps, see pages 148 to 154.

Prices of Portable Pumping Engines, Fig. 296.

Diameter of pump in inches	6	8
Nominal horse-power of engine	5	8
Number of gallons delivered per hour	8000	14,500
Approximate weight packed in cwts.	95	117
Approximate measure packed in cubic feet	318	415
Price complete with brass-lined pump	£220 0 0	£280 0 0
Extra for packing for shipment	£6 0 0	£9 0 0

THE PORTABLE LIFT and FORCE PUMP, and CATTLE GEAR, Fig. 297, was originally designed for irrigation, but it is applicable for any other purpose where fluids have to be raised; and whilst exceedingly portable and compact, it is so simple in construction and in the mode of working, that it can be set in operation in a few minutes by inexperienced men. The pinion driven by the large spur-wheel has a disc plate and crank pin on its upper side, and this crank pin working in a slotted link or cross-head, as shown, drives the pumps. The valves are plain india-rubber discs with grids and guards, and can be easily got at for examination by removing the covers provided for that purpose on the valve chests. The portable pumps are fitted for hose unions for the suction and delivery pipes, but for fixed pumps (without travelling wheels) they are usually arranged for flanged pipes. The poles are fitted with whipple trees, and are used as draft poles when the pump is moved from one place to another. These pumps are generally driven by horses or bullocks, but they can be arranged for driving by steam power. They were especially designed for use in India, where they are employed for irrigation, and are strong, simple, and durable, easily moved from place to place, and occupying little space when not employed.

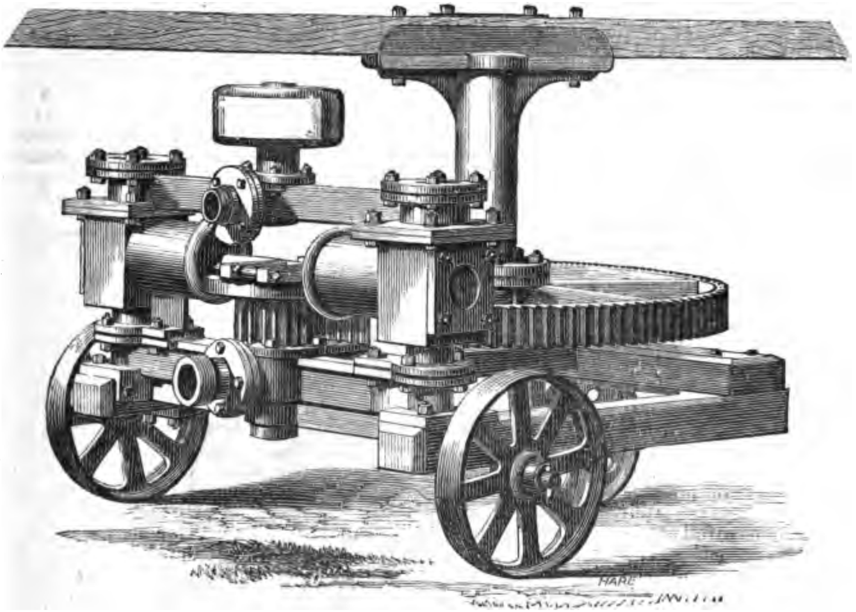

Fig. 297.

If the pumps are required for travelling long distances over bad roads, the wheels should be larger in diameter and width than shown in the engraving, and the front wheels should be fitted to a locking fore-carriage, with bullock poles or shafts. The extra cost of these is from £10 to £15.

For the cost of pipes and fittings suitable for use with these pumps see page 151. The subjoined prices include an air vessel over each valve box, and everything necessary for working excepting the suction and delivery pipe; the results stated are obtained with cattle travelling at a speed of from two to three miles an hour.

PRICES OF PORTABLE PUMP AND CATTLE GEAR, Fig. 297.

Diameter of pump in inches ..	3	4	6	8
„ suction pipe in inches	2	2½	3½	5
„ delivery pipe in „	1½	2	3	4
Gallons delivered per hour ..	500 to 700	1000 to 1300	3000 to 4000	5000 to 7000
Approximate weight in cwts. ..	120	15	17	20
Price without travelling wheels	£26	£32 0	£39 0	£52 0
„ complete as shown ..	£28	£34 5	£41 12	£55 5

Packing for shipment, 4 per cent.

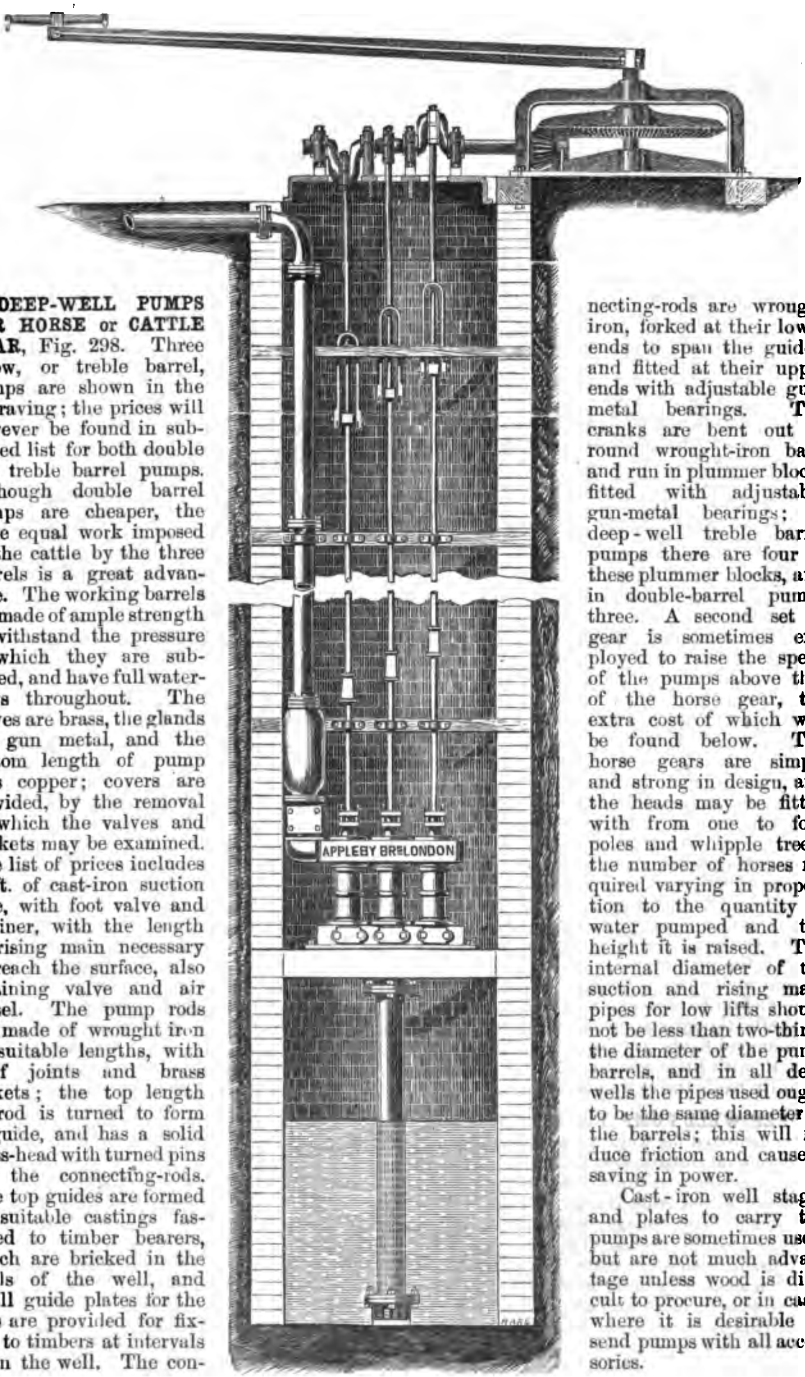

Fig. 298.

DEEP-WELL PUMPS FOR HORSE or CATTLE GEAR, Fig. 298. Three throw, or treble barrel, pumps are shown in the engraving; the prices will however be found in subjoined list for both double and treble barrel pumps. Although double barrel pumps are cheaper, the more equal work imposed on the cattle by the three barrels is a great advantage. The working barrels are made of ample strength to withstand the pressure to which they are subjected, and have full waterways throughout. The valves are brass, the glands are gun metal, and the bottom length of pump rods copper; covers are provided, by the removal of which the valves and buckets may be examined. The list of prices includes 20 ft. of cast-iron suction pipe, with foot valve and strainer, with the length of rising main necessary to reach the surface, also retaining valve and air vessel. The pump rods are made of wrought iron in suitable lengths, with scarf joints and brass sockets; the top length of rod is turned to form a guide, and has a solid cross-head with turned pins for the connecting-rods. The top guides are formed by suitable castings fastened to timber bearers, which are bricked in the walls of the well, and small guide plates for the rods are provided for fixing to timbers at intervals down the well. The connecting-rods are wrought iron, forked at their lower ends to span the guides, and fitted at their upper ends with adjustable gun-metal bearings. The cranks are bent out of round wrought-iron bars, and run in plummer blocks fitted with adjustable gun-metal bearings; in deep-well treble barrel pumps there are four of these plummer blocks, and in double-barrel pumps three. A second set of gear is sometimes employed to raise the speed of the pumps above that of the horse gear, the extra cost of which will be found below. The horse gears are simple and strong in design, and the heads may be fitted with from one to four poles and whipple trees; the number of horses required varying in proportion to the quantity of water pumped and the height it is raised. The internal diameter of the suction and rising main pipes for low lifts should not be less than two-thirds the diameter of the pump barrels, and in all deep wells the pipes used ought to be the same diameter as the barrels; this will reduce friction and cause a saving in power.

Cast-iron well stages and plates to carry the pumps are sometimes used, but are not much advantage unless wood is difficult to procure, or in cases where it is desirable to send pumps with all accessories.

PRICES OF TREBLE (BRASS) BARREL DEEP-WELL PUMPS.

Diameter of pump barrels in inches	3	3½	4	5
Number of gallons raised per hour at 20 strokes per minute ..	760	980	1350	2100
Number of gallons raised per hour at 30 strokes per minute ..	980	1350	1900	2900
Price complete to crank shaft for well 30 feet deep	£87 10 0	£95 0 0	£112 0 0	£135 0 0
Price extra for each foot increased depth	£0 5 0	£0 5 6	£0 6 0	£0 7 6

PRICES OF DOUBLE (BRASS) BARREL DEEP WELL PUMPS.

Diameter of pump barrels in inches	3	3½	4	5
Number of gallons raised per hour at 20 strokes per minute ..	500	650	900	1500
Number of gallons raised per hour at 30 strokes per minute ..	700	900	1200	2000
Price complete to crank shaft for well 30 feet deep	£63 0 0	£66 0 0	£72 0 0	£105 0 0
Price extra for each foot increased depth	£0 4 0	£0 4 6	£0 5 0	£0 6 0

Price extra for gear to increase speed of pump above that of horse gear, £6 to £10.

PRICES OF SINGLE SPEED HORSE GEAR, Fig. 300.

Number of poles	1	2	4
Apportionate weight in cwts.	13	14	20
Price including poles and whipple trees	£14 0 0	£16 0 0	£23 10 0
Price of ditto if frame-work is of wrought iron ..	£16 0 0	£20 0 0	£30 0 0

The horse gears are strong and durable, the teeth of the gear employed are carefully proportioned and shaped to work with as little friction as possible, and the poles are made of well-seasoned timber and are strengthened by wrought-iron tie rods. The price above does not include a long length of shaft to connect up to the pump crank shaft, the cost being based on the arrangement shown in figure, when the pinion is keyed on to the end of pump shaft and the horses or cattle walk round the well. If it is desired to place the horse gear further from the well the price will be slightly increased by the cost of the necessary shafting and couplings; in some such cases it is found convenient to use universal couplings of the usual kind. The Author's firm have constructed a number of horse gears in which everything but the bearings for the shafts, the gear and the poles, was constructed of wrought iron. These gears are made for the diamond fields in South Africa and elsewhere, for the express purpose of obtaining great strength with little weight. If such machinery has to be carried a long way up country over bad and hilly roads the extra cost is more than compensated for by reduced freight.

DEEP-WELL PUMP, Fig. 299. This is suitable for wells not exceeding 100 feet in depth, and is arranged for working with horse, pony, or cattle gear.

In general construction these pumps closely resemble those shown in Fig. 298, but they vary slightly in some details, the buckets being generally, though not necessarily, fitted with Appleby's patent conical valves. Doors are not provided for examination of valves. The strainer on the end of the suction pipes, can have a foot valve if required at a small extra cost. The barrels are made of brass. The rising main is provided with an air vessel and retaining valve, and sufficient pipe to convey the water to the top of the well; the cost of piping required to convey it from that point to any other place may be found at pages 148 to 154.

The lowest length of pump rods are of copper, and work through gun-metal glands; the rest of the rods are of wrought iron with scarf joints and brass sockets. The upper end of top pump rod is turned to form a guide, and has a solid cross-head with pins for the connecting-rod to work on. The connecting-rods are of wrought iron, forked to span the guides and fitted at the top with adjustable gun-metal bearings. The guides are formed by castings suitable for fixing to timber bricked into the side of the well. The well frame is formed by a strong casting carrying the crank shaft bearings; these are plummer blocks fitted with adjustable gun-metal bearings, loose caps and bolts. The crank shaft is bent out of a wrought-iron bar and turned in the journals. A heavy fly-wheel is keyed on to the crank shaft to give it a regular and uniform motion. The subjoined prices do not include well stages or guides, these being usually made of timber and bricked into the wall of the well, as shown in engraving, when the well is made. The pumps are arranged to be driven by steam power or from horse gears similar to those previously described. The number of horses required to work a pump will of course depend on the quantity of water lifted and the height to which it is raised.

The horse-power gear usually supplied with these pumps is similar to that illustrated by Figs. 298 and 300, the prices for which will be found on the preceding page.

Separate prices for deep-well pumps are given at p. 100, and the cost of cranks and crank frames at p. 66. With this, and the other data given in this Section, approximate estimates may be made of the cost of pumps of almost any capacity and for almost any depth.

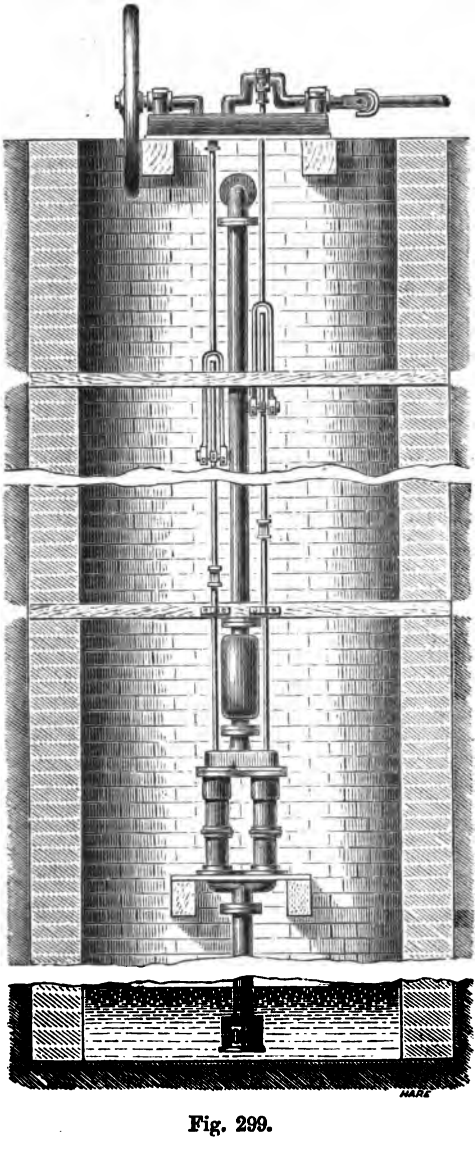

Fig. 299.

Prices of Treble Barrel Deep-Well Pumps, Fig. 299.

Diameter of barrels in inches	2½	3	3½
Number of gallons pumped per hour ..	570	810	1100
Price of pumps for well 30 feet deep ..	£45 0 0	£49 0 0	£55 0 0
Extra per foot for increased depth ..	£0 4 0	£0 4 6	£0 5 0
Extra for air vessel and retaining valve	£1 15 0	£2 2 0	£2 5 0

Prices of Double Barrel Deep-Well Pumps.

Diameter of barrels in inches (brass) ..	2½	3	3½
Number of gallons pumped per hour ..	380	510	740
Price of pumps for well 30 feet deep ..	£30 0 0	£33 0 0	£35 0 0
Extra per foot for increased depth ..	£0 2 10	£0 3 3	£0 3 6
Extra for air vessel and retaining valve	£1 5 0	£1 5 0	£1 10 0

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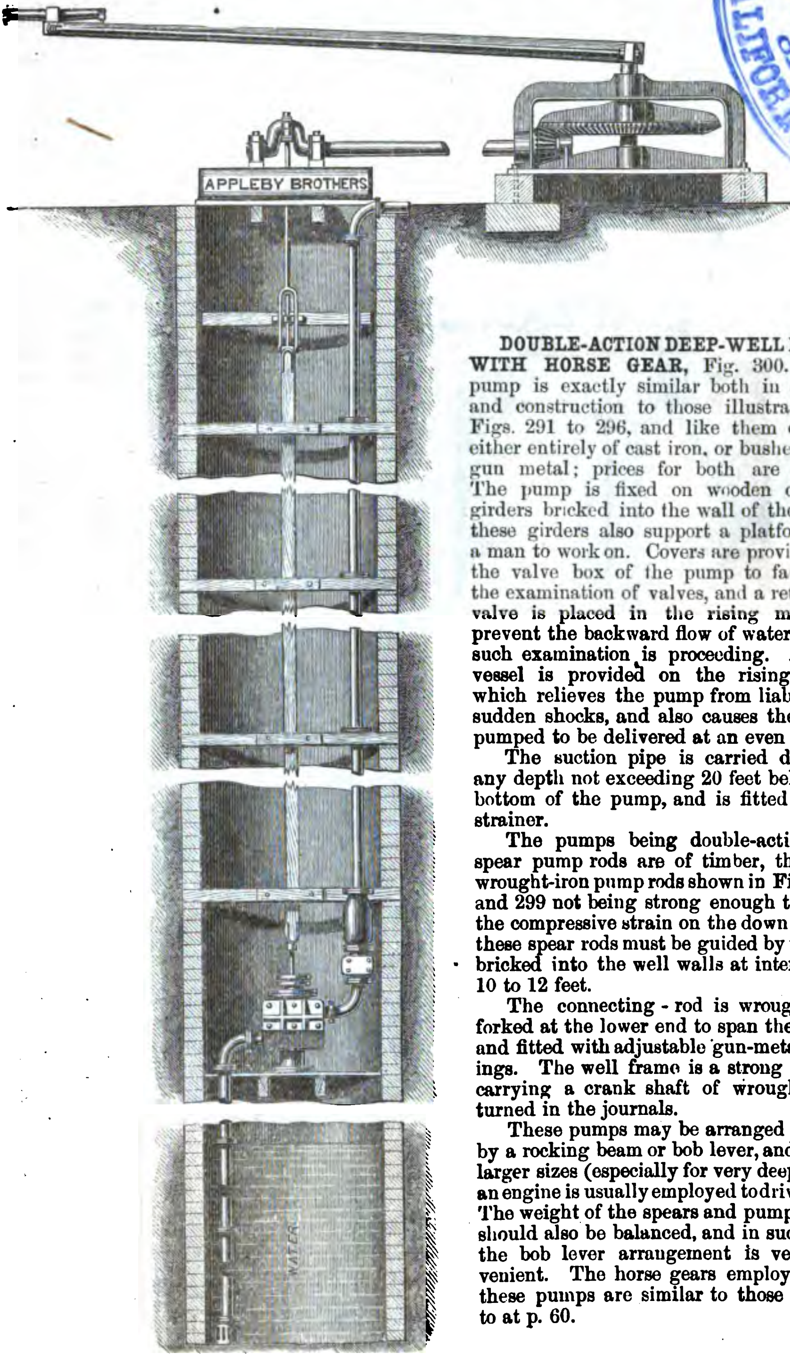

Fig. 300.

DOUBLE-ACTION DEEP-WELL PUMP WITH HORSE GEAR, Fig. 300. This pump is exactly similar both in design and construction to those illustrated in Figs. 291 to 296, and like them can be either entirely of cast iron, or bushed with gun metal; prices for both are given. The pump is fixed on wooden or iron girders bricked into the wall of the well; these girders also support a platform for a man to work on. Covers are provided on the valve box of the pump to facilitate the examination of valves, and a retaining valve is placed in the rising main to prevent the backward flow of water whilst such examination is proceeding. An air vessel is provided on the rising main, which relieves the pump from liability to sudden shocks, and also causes the water pumped to be delivered at an even rate.

The suction pipe is carried down to any depth not exceeding 20 feet below the bottom of the pump, and is fitted with a strainer.

The pumps being double-acting the spear pump rods are of timber, the light wrought-iron pump rods shown in Figs. 298 and 299 not being strong enough to stand the compressive strain on the down stroke; these spear rods must be guided by timbers bricked into the well walls at intervals of 10 to 12 feet.

The connecting - rod is wrought iron forked at the lower end to span the guide, and fitted with adjustable gun-metal bearings. The well frame is a strong casting carrying a crank shaft of wrought iron turned in the journals.

These pumps may be arranged to work by a rocking beam or bob lever, and in the larger sizes (especially for very deep wells) an engine is usually employed to drive them. The weight of the spears and pump bucket should also be balanced, and in such cases the bob lever arrangement is very convenient. The horse gears employed with these pumps are similar to those referred to at p. 60.

GEARED WELL ENGINE FRAME, Fig. 301, for deep-well pumps, either single, double, or treble barrelled, and can be arranged for hand or steam power, or for both. The frames are cast iron, of a substantial and neat pattern, and are fitted with adjustable gun-metal bearings. The shafts are wrought iron (cast-iron crank shafts are not trustworthy), the cranks being formed by bending the solid bar, thus retaining the whole of the original strength. Wrought-iron screwed stay bars are provided to hold the frames firmly in their relative positions, and the base-plate has holes in it for foundation bolts. The gearing consists of a cast-iron wheel, and pinion of the necessary proportion and strength. The prices include wrought-iron forked connecting-rods fitted with gun-metal adjustable bearings, slings, and guide motion ready to connect up to the pump rods, a heavy cast-iron fly-wheel and two handles, or a pulley turned on the face for driving by power.

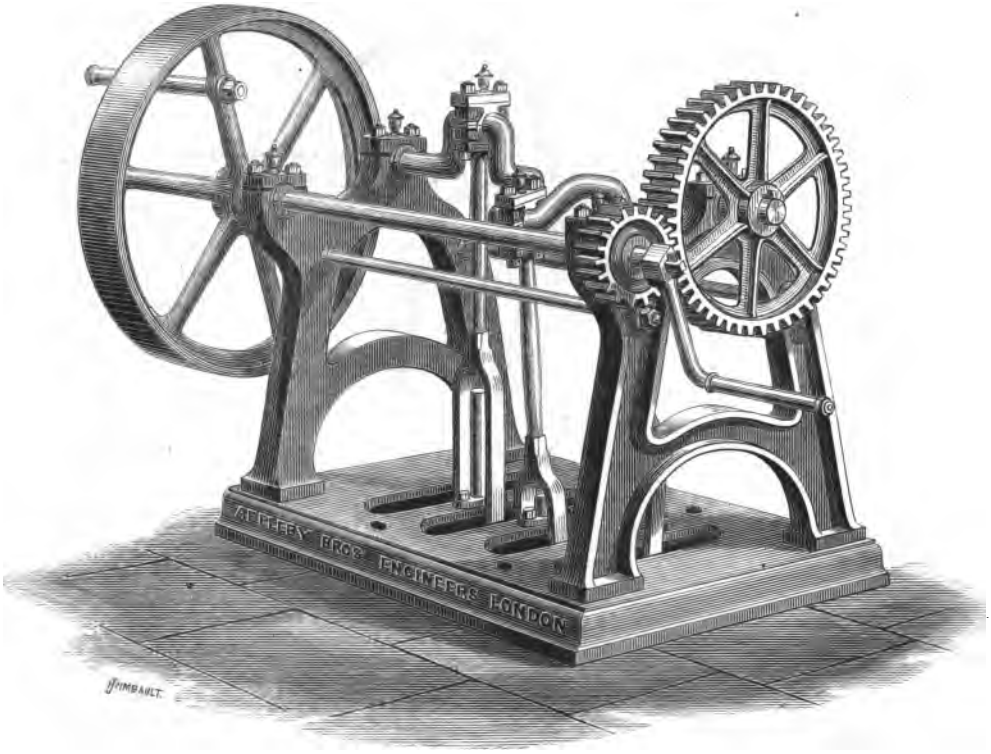

Fig. 301.

PRICES OF GEARED WELL ENGINE FRAMES, Fig. 301.

Price for single crank frame with guides as shown	£21 10 0
„ double „ „	£26 10 0
„ treble „ „	£35 0 0

Packing for shipment about 3 per cent.

If turned pulleys are required in addition to the fly-wheel, the cost is increased in proportion to the size of pulleys. See "Turned Pulleys," Section 7.

STRONG WELL ENGINE FRAME, Fig. 302, is suitable for wells not exceeding 100 feet deep, and for single or double pumps. The frames are neat and strong, and are fitted with gun-metal adjustable bearings for the crank shaft. Wrought-iron stays are provided to hold the frames firmly in their relative positions. The frames are bolted to a strong cast-iron base-plate, to which is also fixed the guide.

The crank shaft is wrought iron turned in the journals, and fitted with cast-iron fly-wheel. The crank is formed by bending the bar, so that the fibres of the metal are continuous, and the full strength of the material retained.

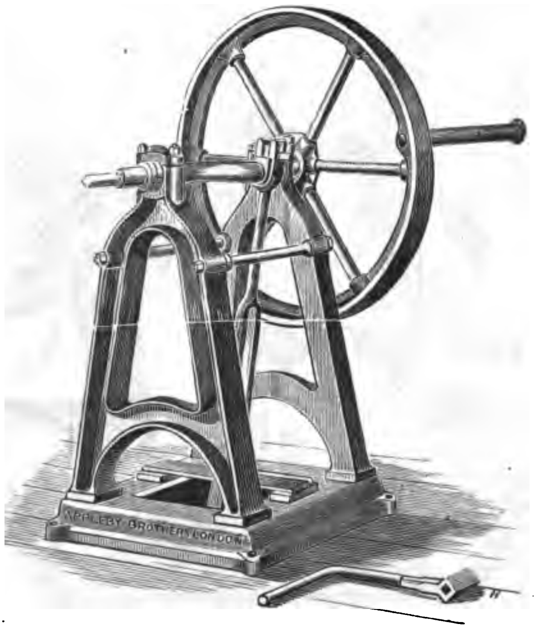

Fig. 302.

The connecting-rod is wrought iron, forked to span the guide and fitted with adjustable gun-metal bearings and cotters.

The guide is bushed with gun-metal, and a wrought-iron guide bar is provided, ready for attaching to pump rods.

Two handles are provided, one fitted on the rim of the fly-wheel, and the other is a wrought-iron cranked handle fitting on the end of the crank shaft.

PRICES OF STRONG WELL ENGINE FRAME, Fig. 302.

Price of frame for single pump..	£14 10 0
„ „ double „	£19 5 0

Cost of packing for shipment about 3 per cent.

If pulleys for steam power are required, the cost of the pulleys must be added. See "Turned Pulleys," Section 7; but in some cases these pumps are driven by round wire ropes working on grooved pulleys. This system was first introduced by the Author's firm for use at the Diamond Fields at Kimberley, Cape of Good Hope. Power is transmitted from the winding engine which is fixed near to the "claim," but the pump is placed where convenient, and by means of the rope the power is carried to almost any distance or in any direction.

STRONG "A" FRAME WELL ENGINE, Fig. 303. This form of well engine is modified for deep or shallow wells. If employed as shown in engraving, it can only be used for wells not exceeding 25 feet in depth, but by placing the barrels below, say, within 15 or 20 feet of the surface of the water, it may be used for much deeper wells. The pump barrels are gun metal, with gland and stuffing box at top; the buckets and valves are also of the same metal. The pump is furnished with a retaining valve in a cast-iron box, fitted with door for examination of valve. The crank shaft is of wrought iron, the cranks being formed by bending the bar so that the fibres of the iron are retained uninjured. The kite guide motion is adopted to enable the pump barrel to be placed above the ground line and still allow the crank shaft to be at the proper level for men to work at handles on the end of it. The side frames are cast iron, triangular in form, and of sufficient height to carry the top guides. The crank shaft bearings are bushed with gun metal. The frames are held apart at the required distance by wrought-iron stays with collars and nuts. A heavy cast-iron fly-wheel is keyed on one end of the crank shaft; one handle is fixed into this fly-wheel, and another fits on the opposite end of the crank shaft.

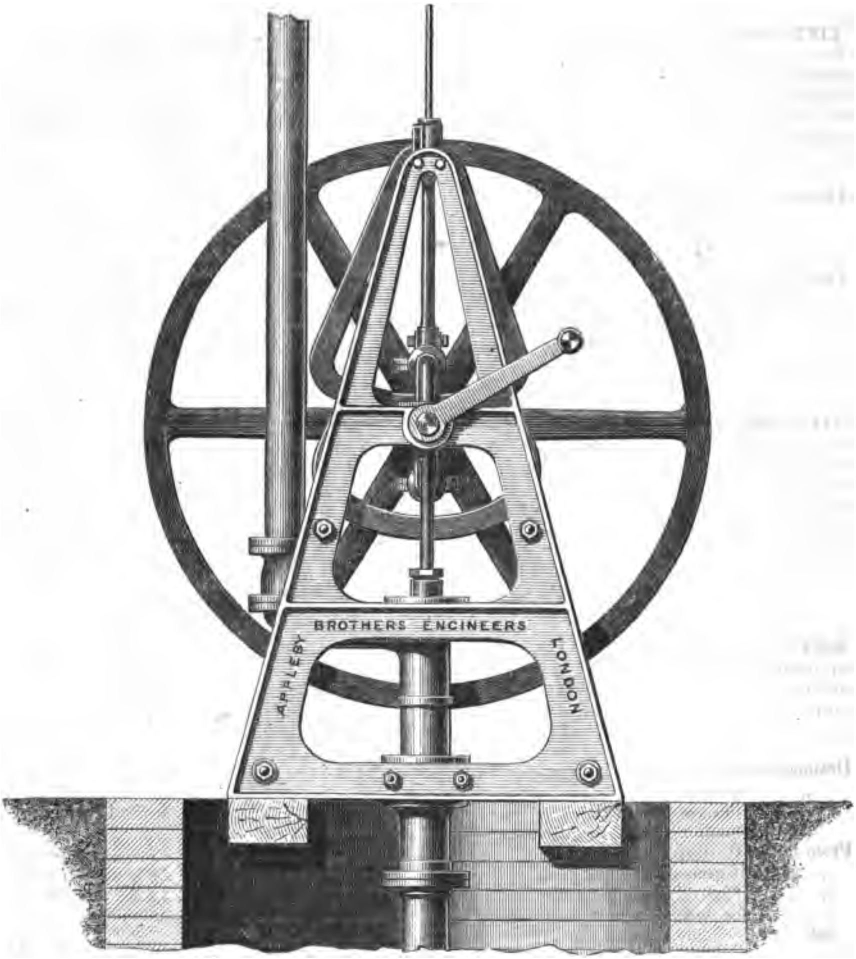

Fig. 303.

The prices include a pair of handles, but no suction or delivery pipes.

PRICES OF WELL ENGINE FRAME, Fig. 303.

Diameter of pumps in inches	3	3½	4
Price complete, as Fig. 303, with double barrels	£32 0 0	£34 0 0	£36 0 0
Ditto, with treble barrels..	42 0 0	46 0 0	50 0 0
Price of frame only for attaching to deep wells, double-barrel pumps	25 0 0	25 0 0	27 0 0
Ditto, with treble-barrel pumps..	28 0 0	30 0 0	32 0 0

LIFT PUMP FOR DEEP WELLS, Fig 304 (No. 102), suitable for depths varying from 27 to 70 feet, is fitted with strong single crank, and the well engine frame is bolted to a cast-iron foundation plate; guide and sling motion, heavy fly-wheel, and two handles are provided; also standard head, main pipe and wood rod, bored working barrel with bucket and clack door, 18′ 6″ of suction pipe, including strainer, bolts, nuts and elastic washers ready for fixing. The general arrangement is similar to deep-well pump, Fig. 303.

Diameter of barrel in inches	2½	3	3½	4
„ main pipe „	3	3	3½	4
„ standard head „	3	3	3	3
„ suction pipe „	1½	2	2½	2½
Price complete for well 30 ft. 6 in. deep ..	£23 15 0	£24 6 0	£25 0 0	£25 16 0
„ extra if exceeding 30 ft. 6 in. deep ..	0 2 6	0 2 6	0 3 0	0 3 6
„ „ if barrel lined with copper ..	0 8 0	0 9 0	0 10 6	0 13 0
„ „ if fitted with brass buckets and valves	0 5 0	0 7 0	0 9 0	0 10 6

LIFT AND FORCE PUMP, Fig. 305 (No. 73), with strong single-crank well engine frame similar to Fig. 304, is fitted and bolted to cast-iron foundation plate 36″ × 18″, with lever guide, heavy fly-wheel 42″ diameter, with balance weight and two winch handles, standard head, 2½″ rising main pipe, 4″ bored working barrel, with clack door and all the latest improvements, wood rods, guides, &c., 3″ T-pipe, 12″ globular air vessel, 2½″ dip pipe to suit rising main, 18 feet of 2½″ suction pipe, including strainer, bolts, nuts, and elastic washers for all the joints.

Price complete for well 30 feet deep	£24 0 0
„ extra if exceeding 30 feet deep, for 2½″ flanged main pipe, wood rod, guide, &c., per foot	0 2 3

LIFT AND FORCE PUMP, Fig. 306 (No. 74), is similar to Fig. 305, but without standard pump head, for taking delivery at a distance from the well. It is supplied with single-crank engine frame with wrought-iron crank, &c., and the working parts below the ground line are in all respects the same as Fig. 304.

Diameter of working barrel in inches	2½	3	3½	4
„ main pipe „	3	3	3½	4
„ delivery branch „	2	2	2½	2½
„ suction pipe „	1½	2	2½	2½
Price for 30 ft. deep	£20 11 0	£21 3 0	£21 18 0	£22 16 0
„ extra if exceeding 30 ft. deep	0 2 6	0 2 6	0 3 0	0 3 6
„ „ if barrel is copper lined	0 8 0	0 9 0	0 10 6	0 13 0
„ „ for brass buckets and valves per set	0 5 0	0 7 0	0 9 0	0 10 6

LIFT AND FORCE PUMP, Fig. 307 (No. 75), is similar to Fig. 306, but with double-cranked well engine frame and two 3½″ working barrels, globular air vessel, &c., as shown.

Price complete, with all accessories for 30 feet deep	£33 18 0
„ extra if exceeding 30 feet deep, per foot	0 3 1
„ „ if fitted with 3″ standard pump head	2 8 0

No. 76 is similar in principle to Fig. 307, but with standard head and rising main pipe bolted to the foundation plate.

Price complete, with all accessories for 30 feet deep	£36 0 0
„ extra if fitted with two fly-wheels	2 8 0
„ „ if fitted with turned pulley for power, 15″ in diameter, and 4½″ on face	1 4 0

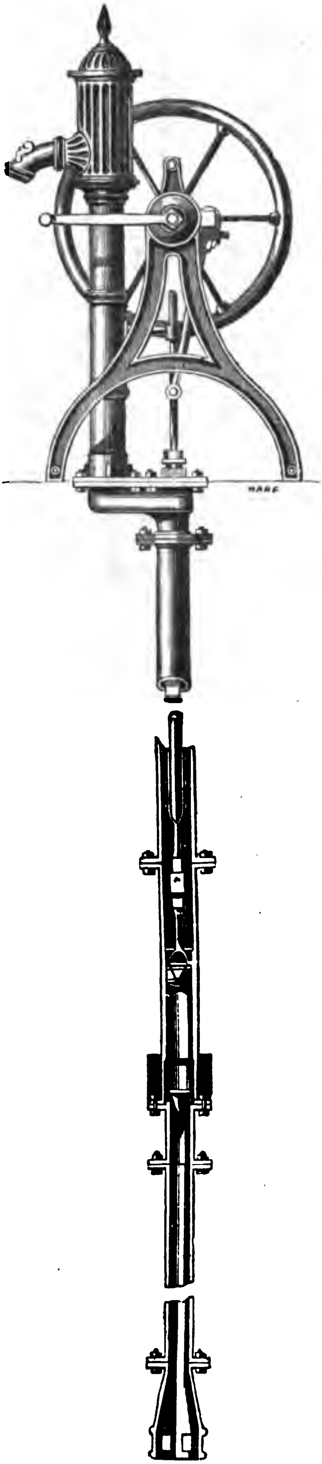

Fig. 304.

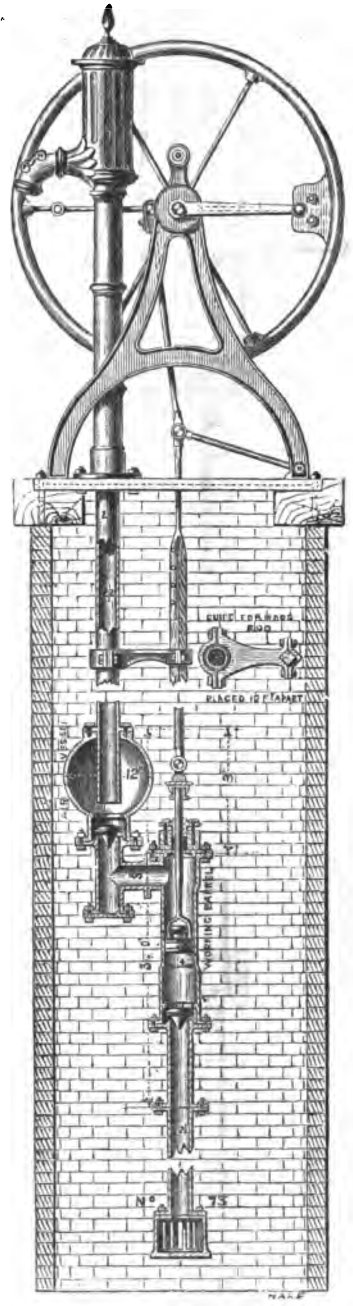

Fig. 305.

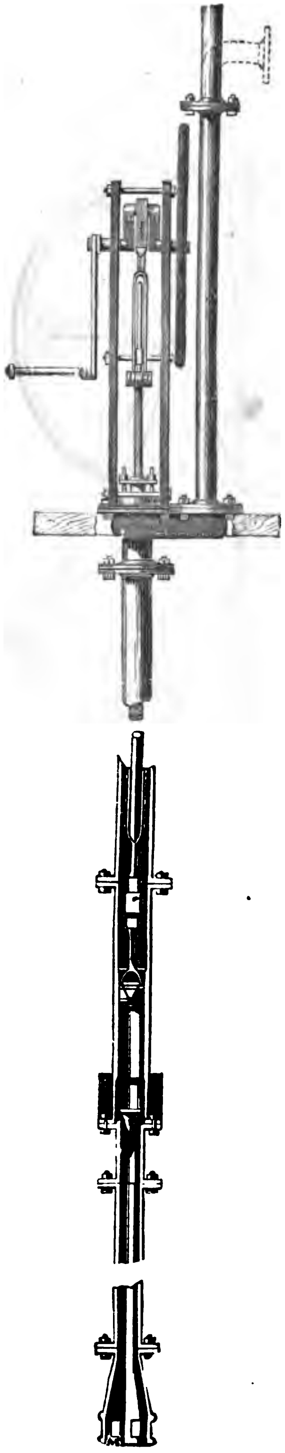

Fig. 306.

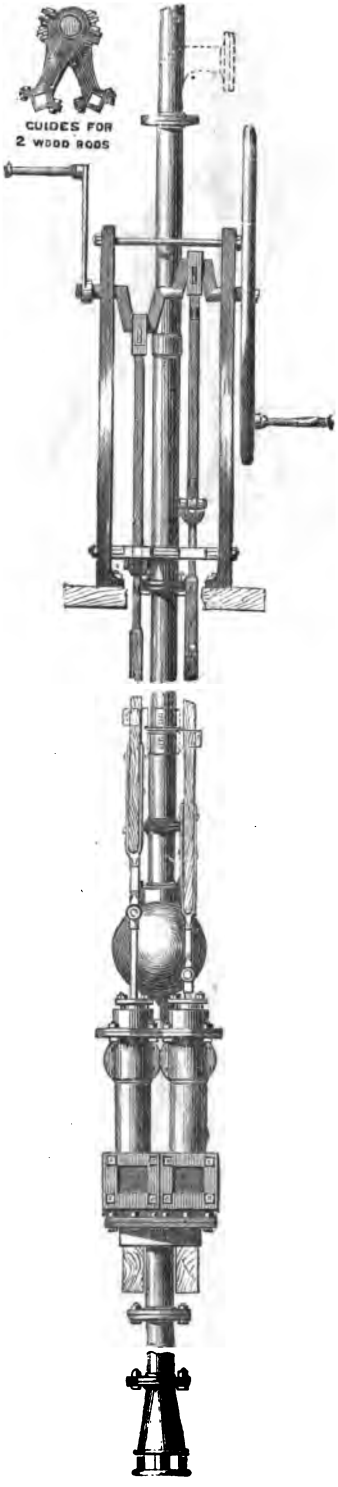

Fig. 307.

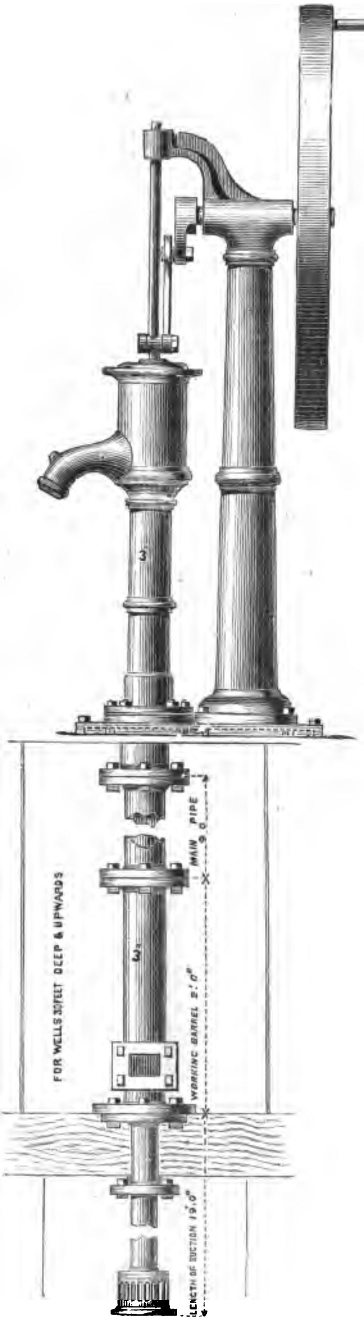

Fig. 308

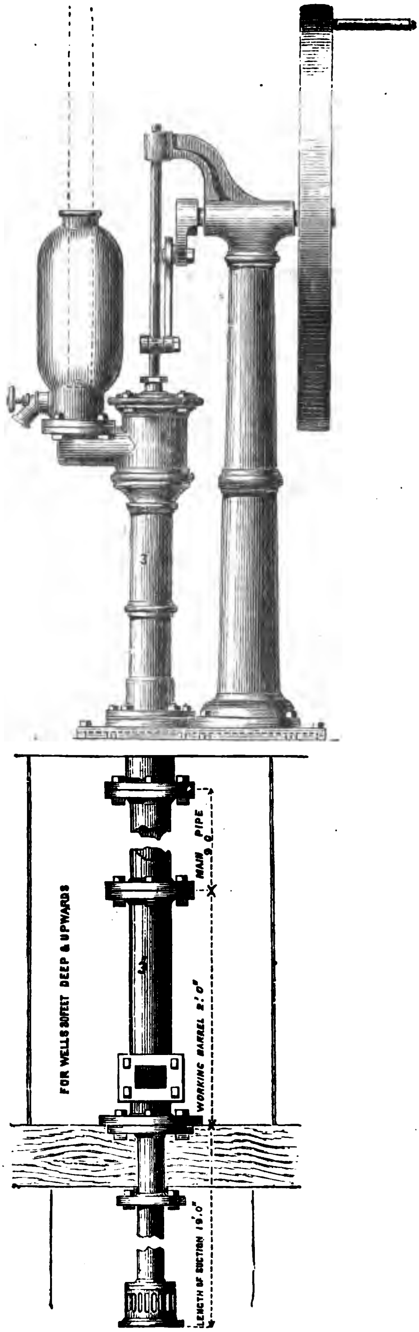

Fig. 309.

No. 77 is a much stronger type of lift and force pump than any of those referred to, having three 3″ working barrels, with doors for access to valves, turned rod and joints, glands and stuffing boxes, elliptical air vessel 18″ × 7″ outside, with retaining valve, strong cast-iron well engine frame fitted and bolted to heavy cast-iron foundation plate 48″×30″, with best wrought-iron three-throw crank, heavy fly-wheel 42″ diameter, 2 winch handles. Spur wheel and pinion to decrease the speed in the ratio of 2 to 1 or 3 to 2, complete with suction pipe, strainer, bolts, nuts and washers for all joints, and 2½″ rising main to ground line.

Price for well 30 feet deep..	£50 0 0
„ extra if exceeding 30 feet deep, per foot	0 4 3
„ „ if fitted with two fly wheels..	2 8 0
„ „ if fitted with turned pulley for power, 15″×4″ ..	1 4 0
„ „ if barrels lined with copper, per set	1 7 0

LIFT AND FORCE PUMP, Fig. 308 (No. 150), for wells from 27 to 50 feet deep, similar in design to Fig. 310. The working barrel is placed 18′ 6″ from the bottom of the well; the prices are for 30 feet deep, and include 9 feet of main pipe and wood rod, 18 feet of suction pipe, and strainer and bolts, nuts and washers, ready for fixing.

Diameter of working barrel in inches	2½	3	3½
Price for 30 ft. deep	£9 12 0	£10 4 0	£11 8 0
„ extra per foot if exceeding 30 ft. deep ..	0 2 6	0 3 0	0 3 6
„ „ with bucket door to barrel	0 10 9	0 12 0	0 14 6
„ „ if barrel is copper lined	0 8 0	0 9 0	0 10 6
„ „ if fitted with brass bucket and valve ..	0 5 0	0 7 0	0 9 0

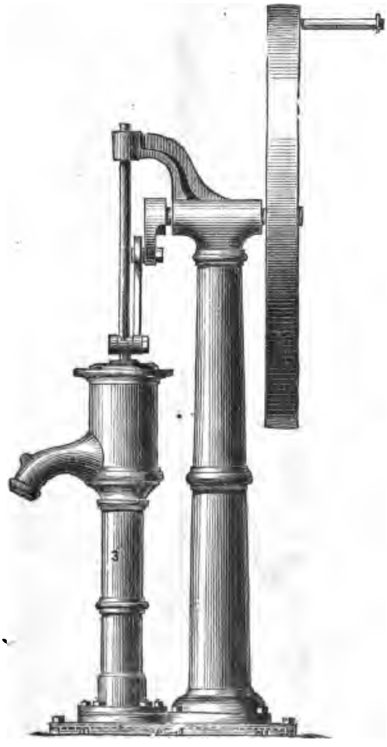

Fig. 310.

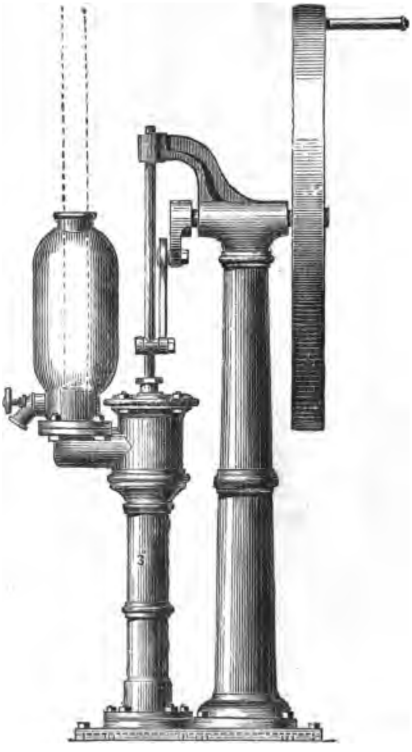

Fig. 311.

LIFT AND FORCE PUMP, Fig. 309 (No. 160), for wells from 27 to 50 feet deep, is similar to Fig. 308, fitted with air vessel and retaining valve complete.

Diameter of working barrel in inches	2½	3	3½
Price for 30 ft. deep	£11 1 0	£12 0 0	£13 4 0
„ extra per foot if exceeding 30 ft. deep	0 2 6	0 3 0	0 3 6
„ „ for draw-off cock	0 7 0	0 7 0	0 7 0
Extras, same as for Fig. 308.			

INDEPENDENT PILLAR PUMP, Fig. 310 (No. 350), for hand or steam power, suitable for wells not exceeding 25 feet deep. The fly-wheels are turned flat on the outer edge to take a strap for steam power if required, and each pump is fitted with patent buckets and valves; the height from the ground to spout varies from 12″ in the small size, to 18″ or 20″ in the larger sizes. With this construction the usual well engine frame and crank is dispensed with, thereby effecting a considerable reduction in cost.

Fig 311 (No. 360) is similar in design and construction to Fig. 310, suitable for wells not exceeding 25 feet, fitted with brass stuffing box, cast-iron air vessel and retaining valve for forcing to a moderate height.

Diameter of barrel in inches	2½	3	3½
„ wrought-iron tube in inches	1¼	1½	2
Price, Fig. 310, each	£6 3 0	£6 12 0	£7 4 0
„ „ 311, exclusive of draw-off cock	£7 15 0	£8 1 0	£8 13 0

DOUBLE-ACTING FORCE PUMP, Fig. 312 (No. 28), suitable for railway stations small waterworks, warehouses, &c. The pump is made of cast iron, very strong in every part, and is fitted with brass plunger; the crank shaft is of wrought iron, turned in the neck and journals, and working in gun-metal bearings. The connecting-rod is of wrought iron, fitted at the upper end with gun-metal bearings. The side frames are of cast iron, stayed together by two wrought-iron stays (the feet being planed for bolting to bed-plate), and fitted with gun-metal bearings, carrying the crank shaft, loose caps, and lock nuts. The whole is mounted on a strong cast-iron base-plate, having planed seats for receiving the side frames. The prices include cast-iron air vessel, fitted with retaining valve, heavy fly-wheel and handle, as shown, also handle for the opposite end of crank shaft. Pulleys for steam power are supplied when desirable, at an extra price, according to the diameter and width necessary for either size.

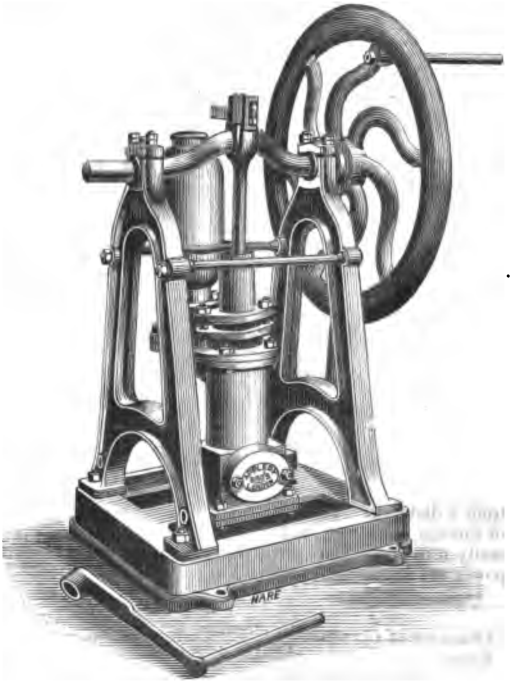

Fig. 312.

Diameter of barrel in inches	4½	5	5½
„ plunger „	3	3½	4
Gallons per hour at 30 strokes per minute, approximately	500 to 600	700 to 800	900 to 1000
Price	£20 0 0	£22 0 0	£28 0 0

DOUBLE-BARREL FORCE PUMP, Fig. 313 (No. 29), designed for station work, ships' use, &c. The barrels are of gun metal with open tops and gun-metal plungers; the crank shaft is of wrought iron, the foundation plate and frames are strong and rigidly stayed together. A large number of these pumps have been fitted with a cast-iron V-wheel for use at the Diamond Fields, Kimberley, &c., for being driven by a wire rope, where the power has been transmitted from a distance. These pumps are extremely simple in construction and well adapted for use in foreign countries, not being liable to get out of order, and, in case of accident, they are easily repaired. The prices include fly-wheel and handle for hand power; pulleys for steam power are supplied at an extra cost, according to the size required.

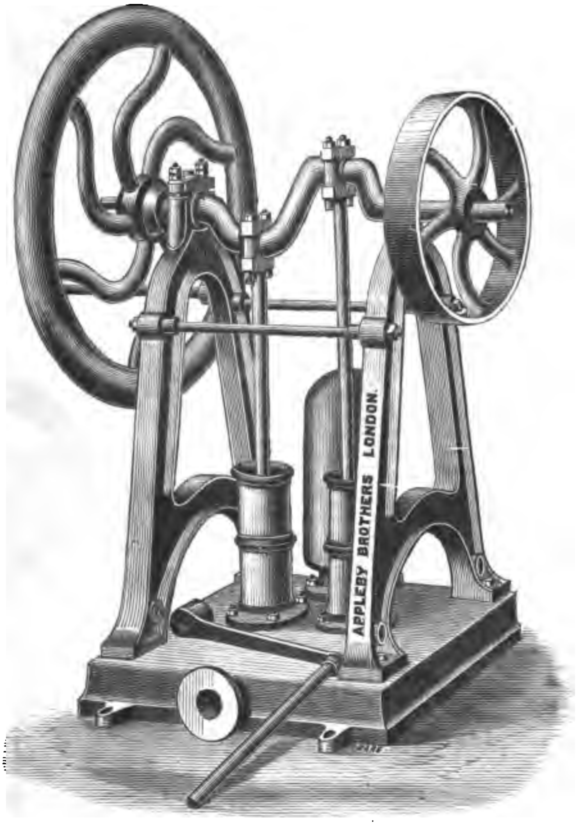
APPLEBY BROTHERS LONDON.

Fig. 313.

Diameter of barrel in inches	2½	3	3½
Price	£20 0 0	£22 0 0	£24 0 0
„ if fitted with V-wheel instead of ordinary fly-wheel	0 10 0	0 10 0	0 10 0
Gallons per hour at 30 strokes per minute approx.	480	625	870

HAND CHAIN PUMP, Fig. 314. This simple form of pump is applicable to such purposes as raising liquid manure, hot or cold water, gas tar, sewage, pulp, grease, clay wash, &c., and will be found extremely useful by brickmakers, potters, builders, contractors, gas companies, or local boards of health.

The arrangement of the pumps is so simple that they seldom get out of order, and can therefore be entrusted to any ordinarily intelligent labourer; if after lapse of time they should require repairs, these can be executed by an ordinary blacksmith. As the pumps are empty when out of use, they are not liable to be injured by frost. Having no valves the pump is not easily choked by weeds or other foreign matter which may happen to find their way into it; for this reason these pumps are applicable where reciprocating pumps would not work satisfactorily. The expenditure of labour required to raise a given quantity of water to a certain height with these pumps is not so much as with a pump worked by a reciprocating lever, the power of a man being more economically employed on a crank handle. Being very light these pumps are easily moved, and require only a few minutes to fix them.

The discs are made of hard, chilled cast iron, and are extremely durable; the chains connecting the discs are made of a good quality of iron, and of ample section. The top and bottom castings are neatly designed, the one to form a spout and carry the chain and fly-wheels, and the other to guide the discs into the barrel. The chain wheel is cast iron with recesses in the rim to fit the discs, and the fly-wheel has a heavy rim and is fitted with handle. Compared to other pumps of equal capacity, they will be found to be economical in first cost, and they are very durable.

The prices given are for 12 ft. from bottom to under side of spout, but they can be adapted for greater heights, and by slightly altering the head pattern and increasing the strength throughout may be employed for very great heights. The prices include every requisite for setting the pump to work.

Prices of Chain Pumps, Fig. 314.

Diameter in inches	3	3½
Height in feet ..	12	12
Gallons per hour ..	2500	5000
Price of pump ..	£4 10 0	£5 10 0
Price per foot extra	0 4 0	0 5 0

Diameter in inches	4½	6
Height in feet ..	12	12
Gallons per hour ..	12,000	16,500
Price of pump ..	£14 14 0	£20 0 0
Price per foot extra	0 12 0	0 15 0

For particulars of other chain pumps, see pages 51 to 54.

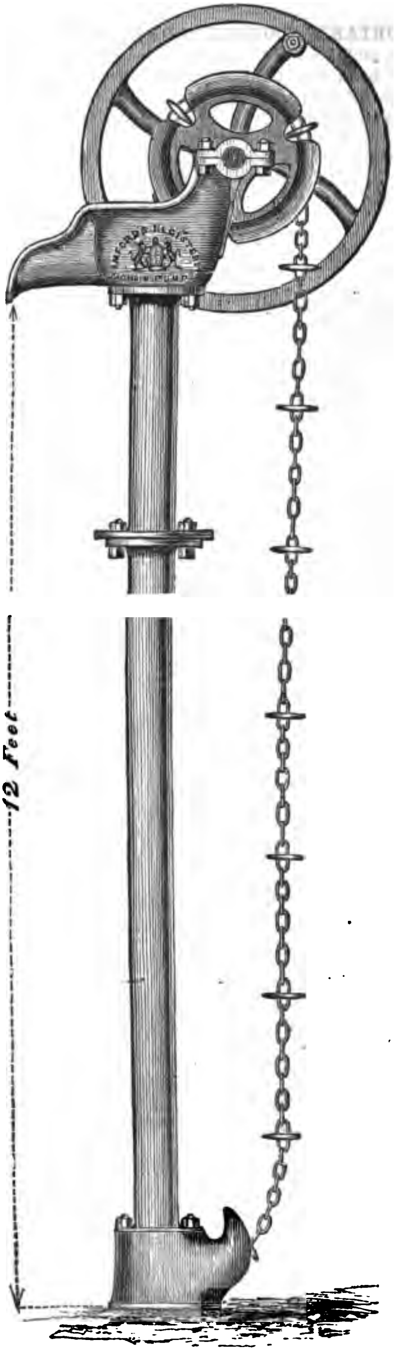

Fig. 314.

PORTABLE DOUBLE-BARREL BRASS PUMP, Fig. 315, shows a portable hand-pump, suitable for all purposes of garden irrigation and prominently as a fire engine. The pump is mounted on four small cast-iron wheels, with wrought-iron axles and carriage. A double wrought-iron rocking handle, with wrought-iron bow handles at ends is provided. An air vessel is provided on the delivery pipe, and the pump is complete in every respect, up to the suction and delivery flanges. The handles can be taken out of their sockets for packing, or if the pump is not required for use, and the wheels can be easily taken off if the pump is required to be bolted down to a deck or floor.

PRICES OF PORTABLE DOUBLE-BARREL BRASS PUMP, Fig. 315.

Diameter of pump in inches	4	5	6
Number of gallons per hour at 40 strokes per minute	1350	2500	5250
Price, complete	£15 0 0	£17 15 0	£21 0 0
„ of suitable (best) suction hose per foot ..	0 5 4	0 5 6	0 5 9
„ „ delivery „ ..	0 3 0	0 3 3	0 3 6

Packing for delivery 5 per cent.

The prices of these pumps, fitted up as hand fire engines, as shown in the engraving, complete with 10 ft. of best suction hose and strainer, and 20 ft. of best delivery hose, with union screws, branch pipe, and jet, are as follows:—

4-inch pump, completely equipped as fire engine			.. .. ..	£23 0 0
5 „ ditto	ditto	ditto	.. .. ..	£27 0 0
6 „ ditto	ditto	ditto	.. .. ..	£32 0 0

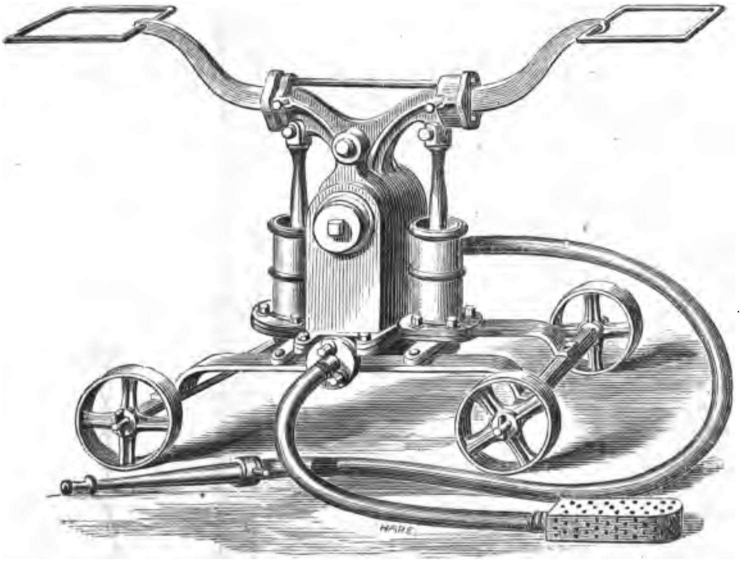

Fig. 315.

PORTABLE CALIFORNIAN PUMP, Fig. 316, illustrates a neat and compact form of portable pump, suitable for several purposes, but specially adapted for use as a fire engine for mansions, farms, dockyards, factories, warehouses, or ships. The pumps are capable of throwing a jet 50 ft. high, and are very strongly proportioned throughout. The carriage is light, but substantial, and is mounted on three wheels, the front one arranged to swivel, and fitted with handle. The pumps are driven by the T-headed levers, sufficiently long for four or six men to work at once.

PRICES OF PORTABLE CALIFORNIAN PUMPS, Fig. 316.

Diameter of barrel in inches	5	6
Price with iron barrel and air vessel and copper piston rod ..	£17 15 0	£21 10 0
„ with brass-lined barrel, iron air vessel, and copper piston rod	19 5 0	23 10 0
„ „ „ copper air chamber, and piston rod	22 0 0	26 0 0
„ completely equipped as fire engine, with 15 ft. of suction and 46 ft. of leather delivery hose, brass couplings, copper branch pipe, and delivery nozzle	30 0 0	36 0 0

For particulars of hose, nozzles, and other fittings, see pages 124, 126, and 142 to 154.

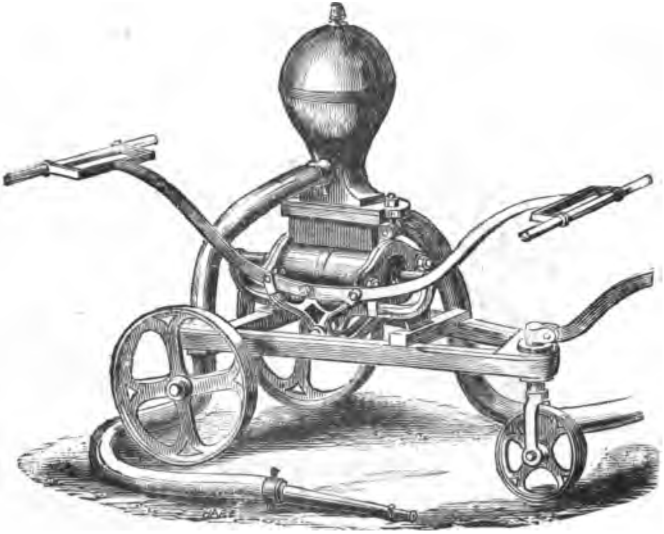

Fig. 316.

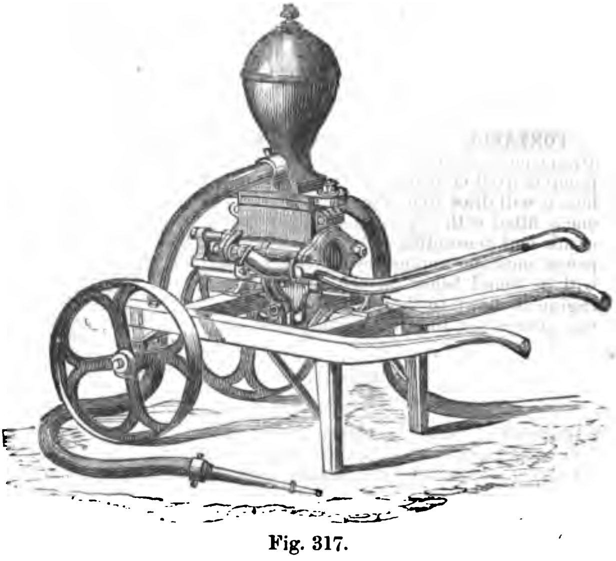

Fig. 317.

CALIFORNIAN BARROW PUMP, Fig. 317, is similar in detail to that last illustrated, but it is mounted on an ordinary barrow, and is suitable for gardens or parks, liquid manures and chemicals, &c. The lever handles are arranged to fit into sockets, so that either one or both may be used as required, and the levers can readily be slipped out when it is desired to move the pump. The barrows are fitted with wrought-iron wheels, and are strong and durable. The construction of the air-vessel and valves is such as to allow the pump to be taken to pieces, cleaned, and set to work again in a few minutes by an ordinary labourer. The smallest size pump (2½ in. diameter of barrel) will throw a

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continuous jet to a height of 40 feet when fitted up as a fire engine, as shown in the engraving. The 2½ in. and 3 in. pumps can be worked as a fire engine by one man, the larger sizes require two men. The subjoined prices include brass unions for hose on suction and delivery, and one handle.

PRICES OF CALIFORNIAN BARROW PUMPS, Fig. 317.

Diameter of barrel in inches ..	2½	3	4	5	6
Price, complete, on barrow	£6 10 0	£7 10 0	£9 5 0	£13 10 0	£18 0 0
Price of pump without barrow ..	5 0 0	6 5 0	8 0 0	10 10 0	15 0 0
Price, extra, per handle	0 5 6	0 5 6	0 5 6	0 5 6	0 5 6

The 5 in. and 6 in. pumps are usually mounted on three-wheeled barrows, as shown in Fig. 316. For prices of hose, unions, nozzles, and other fire engine fittings, see pages 124, 126, and 142 to 154.

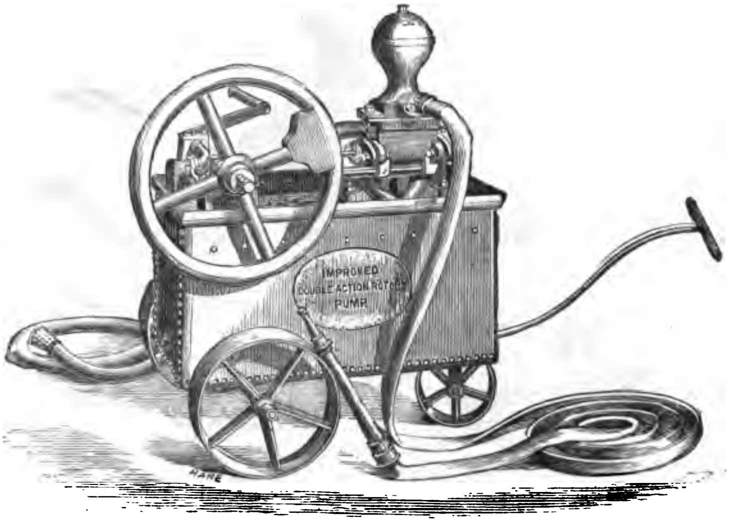

Fig. 318.

PORTABLE CALIFORNIAN PUMP ON TANK, Fig. 318, shows a neat and compact arrangement, useful as a fire engine for farm or mansion, or for irrigation or garden use. The pump is fixed on a strong wrought-iron tank from which it draws its water, or by using suction hose it will draw from a pond or river. The tank is mounted on three iron wheels. The front one is fitted with a wrought-iron handle, and is arranged to swivel. The pump is driven by a crank and connecting-rod, and can be worked either by hand or steam; in the latter case the power must be applied by a leather or india-rubber belt on the rim of the fly-wheel. Prices will be found below for the pump on tank, and for the whole completely equipped as a fire engine as shown in the engraving; this latter includes 12 ft. of suction hose, with union and rose or strainer, 40 ft. of delivery hose, with union, and branch pipe and jet.

PRICES OF CALIFORNIAN PUMP ON TANK, Fig. 318.

Diameter of barrel in inches	2½	3
Price of pump	£13 0 0	£14 5 0
Price of pump, equipped as fire engine	20 15 0	23 15 0

These pumps can be had arranged on a cast-iron frame instead of a tank, at the same prices.

CALIFORNIAN PUMP ON PLANK, Fig. 319. This pump is worked by either one or two handles, removable at pleasure, and secured in their sockets by set screws. The pump is double acting and consequently the water is delivered in a continuous stream. The pump is suitable for wells not exceeding 25 feet deep, either for delivery at the spout, for forcing to any required height through the upright pipe, or by attaching a hose and hand pipe with jet; in the last manner it forms an economical and efficient fire or garden engine. The cock marked C on the engraving is a three-way cock, bolted to the flange of the delivery outlet, and is an important addition to the pump. The vertical outlet is screwed for a wrought-iron rising main, the other for a hose union; there is a hook on the latter, upon which a bucket may be hung when the hose is removed. The price of these three-way cocks given in the list below includes a hose union.

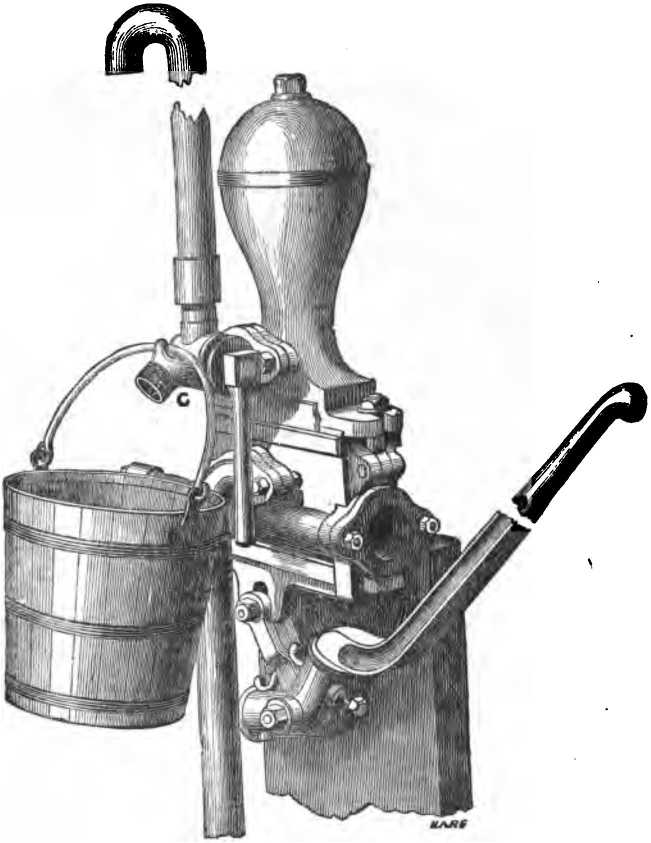

Fig. 319.

The arrangement of the air vessel and valves is such that it can be taken to pieces, cleaned, and put together again in a few minutes, by an unskilled labourer.

The prices include one handle and every requisite for working the pump except suction and delivery pipes.

PRICES OF CALIFORNIAN PUMP ON PLANK, Fig. 319.

Diameter of bore in inches	2½	3	4	5	6
No. of gallons delivered per hour ..	360	600	1020	1620	2400
Price of pump only	£4 8 0	£5 10 0	£7 0 0	£8 15 0	£13 10 0
Price of three-way cock	1 0 0	1 1 0	1 7 6	1 15 0	3 0 0
Price extra for one handle	0 5 0	0 5 0	0 5 0	0 5 0	0 5 0

For particulars of hose, unions, and jets, see pages 142 to 154.

INTERMEDIATE DRIVING GEAR, Fig. 320, shows a neat, compact, and strong set of gear suitable for driving deep well, mining, or contractors' pumps. The wheels are carefully proportioned, the teeth being of a form calculated to work with as little noise and friction as possible, and consequently to wear well. The frames are cast iron, of a neat and strong pattern, provided with seats for two plummer blocks, lugs for holding down bolts, and bosses for stays; the latter are four in number, wrought-iron collar stays, screwed at ends. There are two pairs of plummer blocks, all fitted with loose caps, bolts, and nuts, and adjustable gun-metal bearings; these plummer blocks are carefully bedded on their seats and wedged in position between joggles. The crank shown in engraving is wrought iron, keyed on to the shaft, but if more convenient this could be replaced by a cast-iron balanced crank arm, having in it three or four holes for crank pin at various distances from the centre of the shaft, enabling the stroke of the pump to be adjusted in proportion to the quantity of water required; the same object may be attained by making the bob lever or bell crank at the top of the well or mine adjustable.

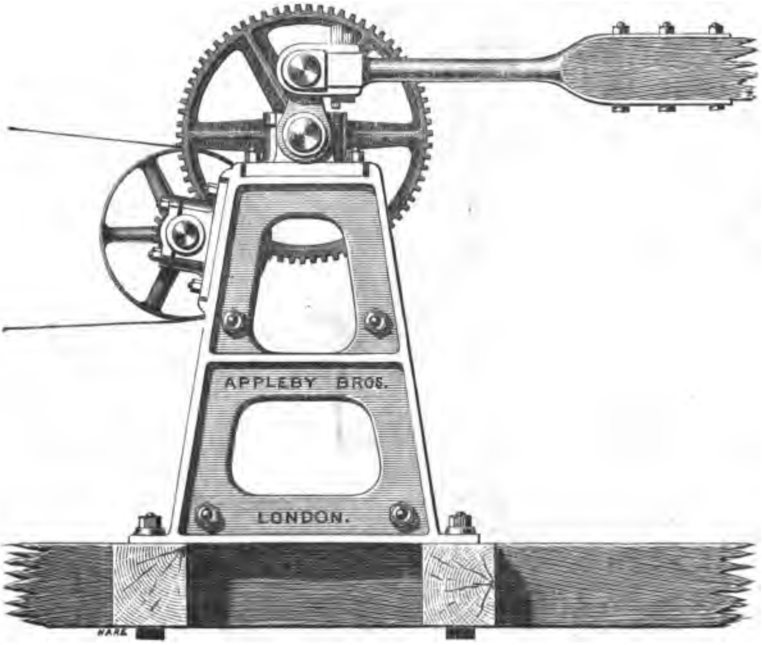

Fig. 320.

The pulley shown on the pinion shaft is cast-iron turned on face and edges, keyed on the shaft and of ample width and diameter to transmit the power necessary for driving a 6 in. or 8 in. double-acting pump, such as shown, Figs. 321 to 325. It is sometimes preferred to take away the strap pulley, and place the frame in such a position that the spur wheel gears with a pinion on the crank shaft of the portable or other engine from which the power is obtained; if a portable is employed in this manner it is necessary to block it up on its wheels very firmly, otherwise the vibration of the engine is likely to break the teeth of the pinion. The price of the gear without the strap, pulley, shaft, and plummer blocks, is given below. The connecting-rods employed in connection with these gears are usually of considerable length, and are therefore composed of a stiff timber rod with wrought-iron ends; these ends are fitted with adjustable gun-metal bearings either of the form illustrated in the engraving with strap and cotters, or of the type known as the marine head, shown in many of the engravings in this book.

The subjoined prices include the frames and gear complete with holding down bolts for 12 in. timber, and one connecting-rod end, but no timber or bell crank end for rod.

PRICES OF INTERMEDIATE DRIVING GEAR, Fig. 320.

Gear complete, with pinion shaft and strap pulley	£24
Gear without ditto ditto	£18

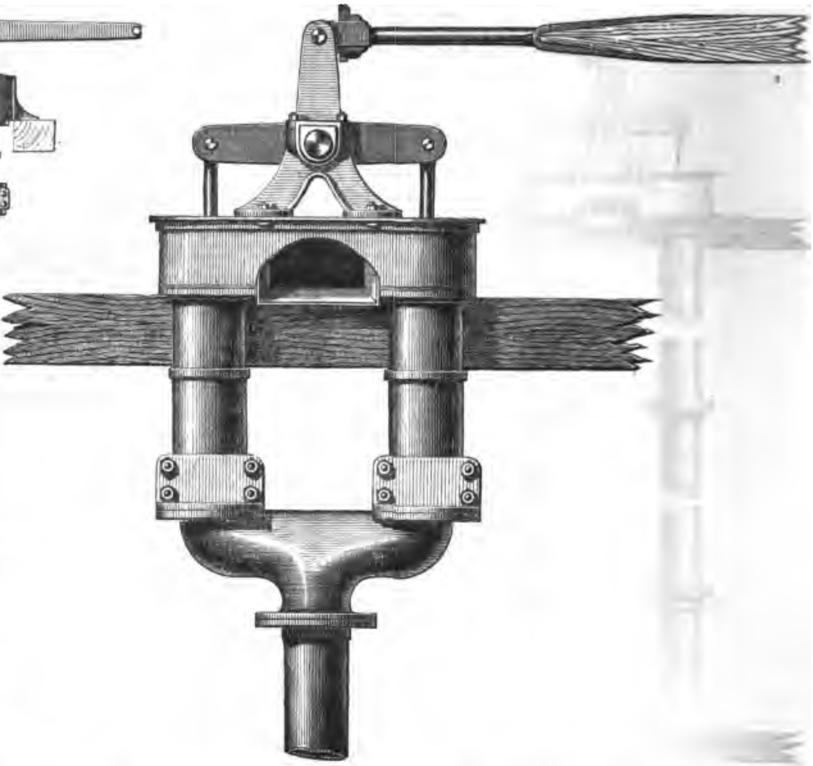

Fig. 322.

DOUBLE-BARREL WROUGHT-IRON CONTRACTORS' PUMPS, Figs. 321 and 322. These pumps are suitable for contractors' use; one is to work by hand and the other by steam power. Fig. 321 is shown with double lever handles for a number of men, and has bored barrels and packed buckets, strong collared flanged pipes, and sliding suction. Fig. 322 has a cistern head of strong wrought-iron plate, stiffened with angle irons; cast-iron bored barrels with door for access to clack valves, and cast-iron buckets packed with hemp, and is so arranged that the bucket can easily be drawn up for examination and repacking. The suction pipes are of wrought iron with strong flanges, and the pump is furnished with a telescopic suction slide. These pumps are used in clearing water from foundations and in the formation of docks, &c. The prices given include rocking or bob lever with bearing, wrought-iron connecting-rod end, fitted with adjustable bearings, and ready for fixing to timber rod, and all necessary bolts and joint rings for a working depth of 28 feet under the spout.

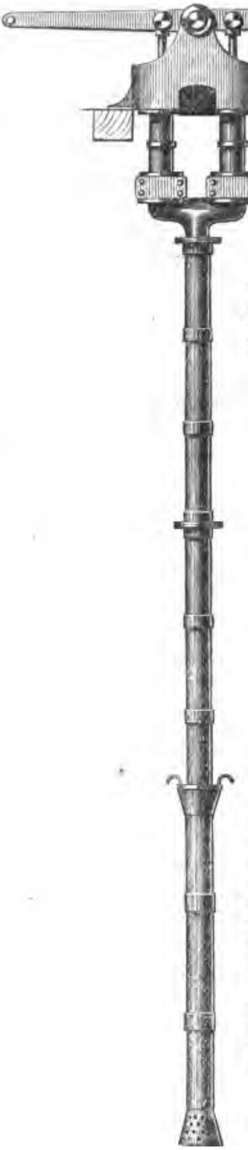

Fig. 321.

PRICES OF CONTRACTORS' PUMPS, Fig. 321.

Diameter of barrels in inches	6	8
Price, complete, for 28 ft. under spout	£30 0 0	£48 0 0
Price, ditto with door for access to valves ..	..	£54 0 0

PRICES OF CONTRACTORS' PUMPS, Fig. 322.

Diameter of barrels in inches	8	10	12	12	15
Stroke of buckets in inches	15	15	16	24	30
Gallons per hour at 30 strokes per minute	9000	15,000	23,500	34,500	65,000
Price complete for 28 ft. below spout ..	£54	£82	£96	£110	£150

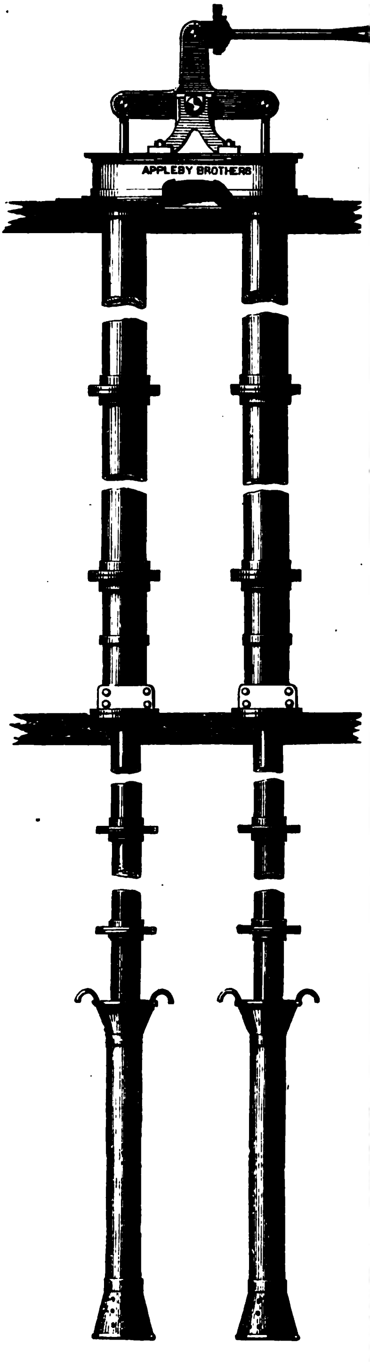

Fig. 323.

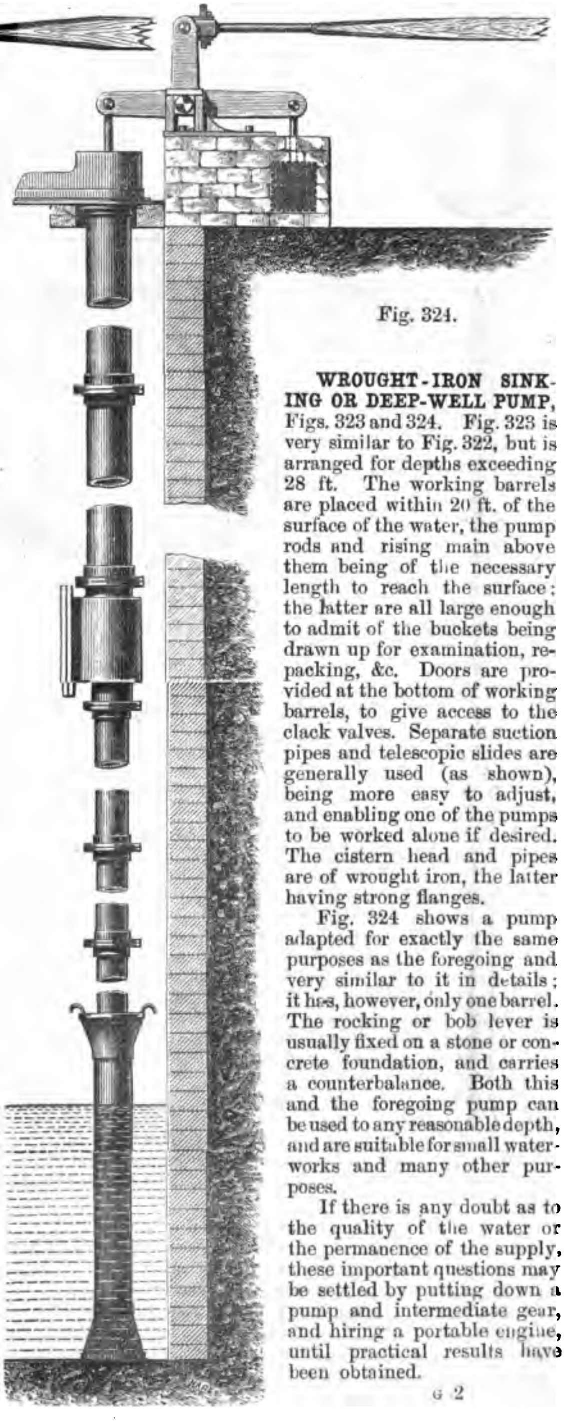

Fig. 324.

WROUGHT-IRON SINKING OR DEEP-WELL PUMP, Figs. 323 and 324. Fig. 323 is very similar to Fig. 322, but is arranged for depths exceeding 28 ft. The working barrels are placed within 20 ft. of the surface of the water, the pump rods and rising main above them being of the necessary length to reach the surface; the latter are all large enough to admit of the buckets being drawn up for examination, repacking, &c. Doors are provided at the bottom of working barrels, to give access to the clack valves. Separate suction pipes and telescopic slides are generally used (as shown), being more easy to adjust, and enabling one of the pumps to be worked alone if desired. The cistern head and pipes are of wrought iron, the latter having strong flanges.

Fig. 324 shows a pump adapted for exactly the same purposes as the foregoing and very similar to it in details; it has, however, only one barrel. The rocking or bob lever is usually fixed on a stone or concrete foundation, and carries a counterbalance. Both this and the foregoing pump can be used to any reasonable depth, and are suitable for small waterworks and many other purposes.

If there is any doubt as to the quality of the water or the permanence of the supply, these important questions may be settled by putting down a pump and intermediate gear, and hiring a portable engine, until practical results have been obtained.

PRICES OF DEEP-WELL OR SINKING PUMPS, FOR A DEPTH OF 50 FEET, Figs. 323 and 324.

Diameter of barrels in inches	8	10	12	12	15
Length of stroke „ ..	15	15	16	24	30
Price of pump, Fig. 323 ..	£90	£130	£175	£185	£250
„ „ 324 ..	£60	£75	£95	£100	£160

For cost of extra length of pipe, see p. 149.

OPEN LIFT PUMP FOR MINES, DEEP WELLS, &c. The pump (Fig. 325) is specially adapted for working at depths of from 50 to 300 feet, where a large supply of water is required as in waterworks, or the sinking of shafts for mines; in tunnels, &c. The working barrel is within 10 ft. of the surface of the water. An iron windbore is bolted to the valve box, which is cast solid with the barrel in small sizes, but in large sizes a separate casting is bolted to the barrel. The foot and bucket valves are of the ordinary Cornish double beat equilibrium pattern, having faces of patent metal, so constructed that when worn they can be melted out, and a fresh seating cast in and faced up without affecting the main body of the valve. The working barrel is cast iron, strongly ribbed and accurately bored, and its flanges are faced and turned on the edges. The rising main, which is slightly larger in diameter than the working barrel, is of wrought iron with strong faced flanges; in small sizes, the pipes have welded, and in large sizes double rivetted longitudinal seams. All bolt-holes in the pipe flanges are accurately drilled to a template, so that the pipes are interchangeable. When the pump is required for sinking the upper length of the rising main consists of a casting turned to fit a stuffing box, having feet to rest on a girder, which is placed across the well. The head of the pump resting in this way allows that portion of it which is below to sink gradually as the excavation proceeds, until a further depth of from 4 to 5 ft. has been reached, when an extra depth of rising main is added, and the work proceeds as before. The pump-rods are of wrought iron, with sockets and keys arranged to be easily disconnected and put together again; the rods are made in lengths to match the lengths of rising main. This type of pump is very suitable for employment with Cornish or other beam engines where a long stroke can be obtained. The advantages obtained are, the readiness with which the pump can be put together and repaired; and the working barrel never being more than 10 ft. from the bottom of the well, its economical working is ensured. The pump does not require the usual stages for fixing, the head-gear resting on the girders at the top, and the windbore on the bottom of the well, or sump. The conditions under which these pumps may be worked are so numerous that it would be difficult to give a list sufficiently comprehensive to cover all cases; and before the cost of such pumps can be estimated, it is necessary to know the quantity of water to be lifted in a given time, and the height to which it is to be raised.

Pumps of this kind are extremely durable, seldom getting out of order or needing repairs, and the large number now at work in our deep mines, many of them for many years past, is the best testimony to their efficiency and economy.

The working barrels are made of any diameter, from 6 in. upwards, and are made longer than the stroke usually required, to avoid the necessity of accurate adjustment, to prevent the bucket striking the bottom.

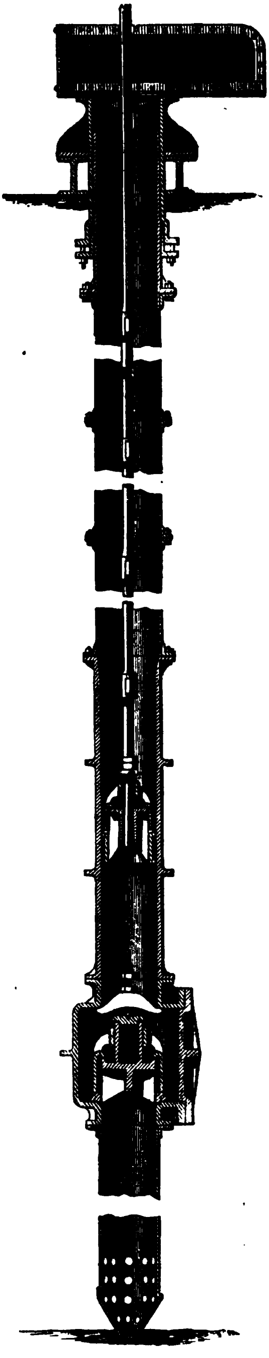

Fig. 325.

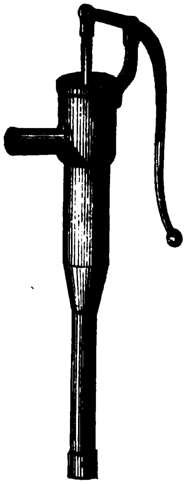

Fig. 326.

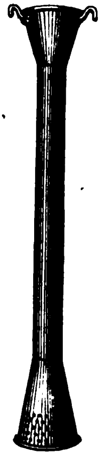

Fig. 327.

WROUGHT-IRON CONTRACTORS' PUMPS, Fig. 326, is a form of pump much used by builders, contractors, and others. They are made very strongly, but at the same time sufficiently light to be easily moved from place to place, as may be desired. The buckets are formed of hard wood, packed with leather, and the valve is also faced with leather, its seat being hard wood. The sliding or telescopic suction pipes used with these pumps are illustrated in Fig. 327; the bottom part is perforated to form a strainer, whilst hooks are provided at the upper end for fixing the pipe in desired position. These pumps are only suitable for use in shallow wells, and cannot be employed when the surface of the water to be raised is more than 28 feet below the pump spout. The joint between the pump and the suction pipe is usually formed by wet clay.

These pumps are sometimes merely painted, and sometimes galvanized; prices will be found in the annexed list for both.

Prices will also be found for pumps very similar to those illustrated by Fig. 326, but with flanged suction pipes; the prices include bolts, nuts, joint rings, and sliding suction complete for 28 feet under the spout.

The prices of pumps for a greater depth than 28 feet will be found on the following page.

PRICES OF WROUGHT-IRON CONTRACTORS' PUMPS, Fig. 326.

Diameter of bore in inches ..	4	5	6	7	8	9
Height under spout in feet ..	7	7	7	7	9	9
Price of pumps, painted	£3 6 0	£3 12 6	£4 10 0	£5 10 0	£8 2 6	£10 4 0
„ „ galvanized ..	3 12 6	4 2 6	5 2 6	6 6 0	10 4 0	12 12 6
„ sliding suction, painted, Fig. 327	2 2 0	2 8 0	2 12 0	2 18 0	3 14 0	4 14 0
„ sliding suction, galvanized, Fig. 327 ..	2 8 0	2 14 0	3 0 0	3 6 0	4 4 0	5 8 0
Price per foot for suction pipe, painted	0 3 9	0 4 4	0 5 0	0 5 6	0 6 9	0 9 0
Price per foot for suction pipe, galvanized	0 4 6	0 5 0	0 5 6	0 6 3	0 8 0	0 11 0

PRICES OF FLANGED CONTRACTORS' PUMPS (28' 0" under spout).

Diameter of pump in inches ..	4	5	6	7
Price complete	£8 5 6	£9 9 0	£11 2 6	£12 15 0

CONTRACTORS' AND WELL SINKERS' WROUGHT-IRON DEEP-WELL PUMPS, Figs. 328, 329, and 330, show three forms of pumps differing slightly in detail, but all suitable for contractors, builders, well sinkers, &c. The pump, Fig. 328, is fitted with a wrought-iron handle, 9 feet of wrought-iron flanged rising main, and bored cast-iron barrel, pump rod and bucket, with leather clack valve (or Appleby's conical valve), suction pipe with telescopic slide and strainer, and complete with all necessary bolts, nuts, and packings for joints, to work to a depth of 36 feet. This pump can easily be applied for working at greater depths by adding to the length of rising main, and correspondingly increasing the length of pump rod. The rising main is made about ½ an inch larger in diameter than the working barrel to admit of the bucket being drawn up for examination or repair. The pump illustrated by Fig. 329 has double wrought-iron lever handle for a large number of men to work at; wrought-iron rising main half an inch larger in diameter than working barrel; cistern head; pump rod, bucket, bored cast-iron barrel, wrought-iron suction pipe with telescopic slide; and is complete with all bolts, nuts, and joint rings necessary for working to a depth of 36 feet. Like the foregoing pump, it can be used for greater depths by lengthening the rising main and pump rods.

The pump, Fig. 330, is generally similar to Fig. 329, except that the rising main pipe is connected by means of union joints instead of flanges. The small diameter of union joints makes the pump very convenient for well sinkers, as it can be passed down a bore pipe. The ordinary telescopic suction and strainer would be inconveniently large in diameter; these are,

therefore, replaced by a fixed suction with union joint and specially-designed strainer. The pump is complete in every respect for a working depth of 36 feet, but can be used for greater depth by increasing the length of rising main and pump rods.

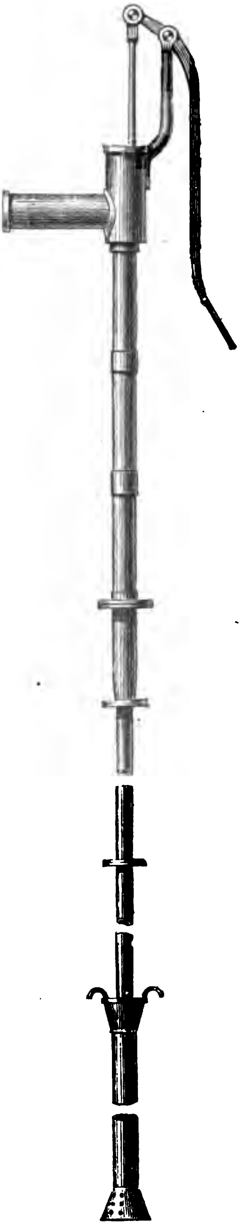

Fig. 328.

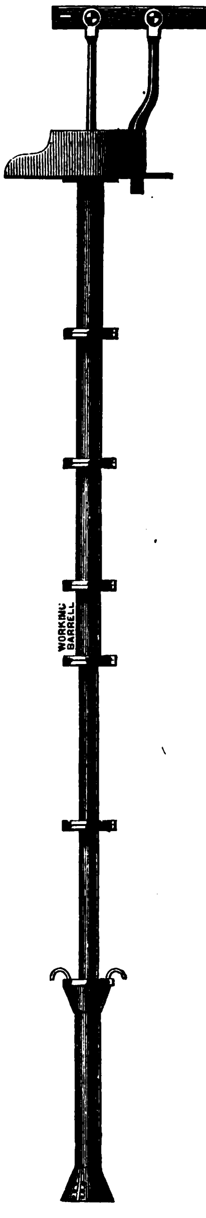

Fig. 329.

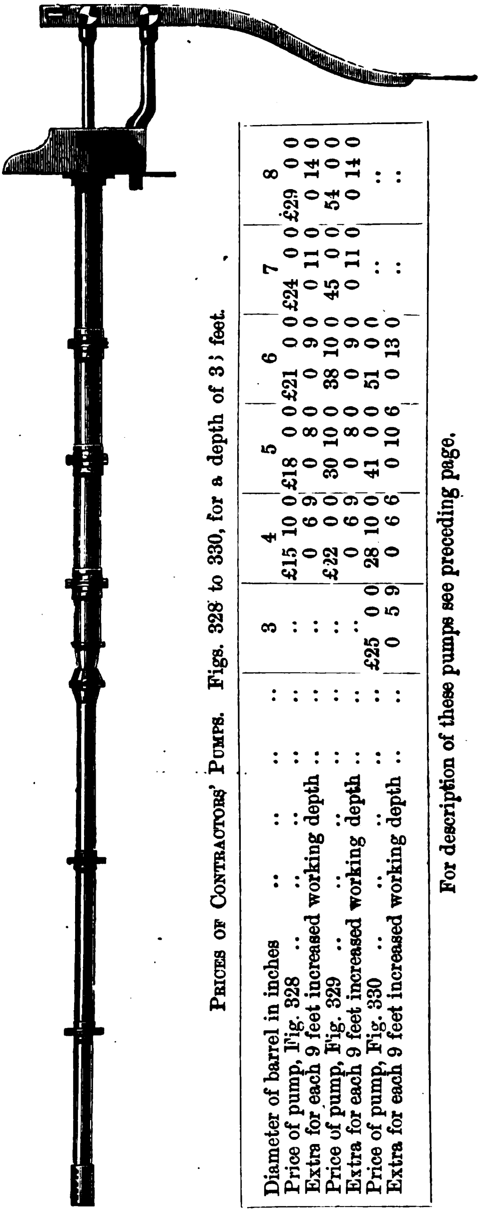

Fig. 330.

PRICES OF CONTRACTORS' PUMPS. Figs. 328 to 330, for a depth of 36 feet.

Diameter of barrel in inches	3	4	5	6	7	8
Price of pump, Fig. 328	..	£15 10 0	£18 0 0	£21 0 0	£24 0 0	£29 0 0
Extra for each 9 feet increased working depth	..	0 6 9	0 8 0	0 9 0	0 11 0	0 14 0
Price of pump, Fig. 329	..	£22 0 0	30 10 0	38 10 0	45 0 0	54 0 0
Extra for each 9 feet increased working depth	..	0 6 9	0 8 0	0 9 0	0 11 0	0 14 0
Price of pump, Fig. 330	£25 0 0	28 10 0	41 0 0	51 0 0	..	..
Extra for each 9 feet increased working depth	0 5 9	0 6 6	0 10 6	0 13 0	..	..

For description of these pumps see preceding page.

APPLEBY'S PUMPS, which are referred to in the following pages, are so widely known that it will be unnecessary to describe them closely in detail; as far as possible, uniformity is preserved in the construction and arrangement. The working barrels are made of cast-iron of close texture, carefully bored, and each pump is fitted with Appleby's patent conical valve and buckets with indestructible packing, which are adapted for use with hot or cold water or pulpy matter; the action of the valve is such that the vacuum is maintained, even when the water contains a large quantity of fibre, grit, &c.

The handles are fixed on the right hand side, unless specially ordered otherwise. These pumps are arranged to suit conditions varying so widely that, for the sake of accuracy, the figure number or number of the pump should always be specified.

The best lubricator for these pumps is water—on no account must oil or grease be used. When required for hot water, oil, or gas tar, they have to be fitted expressly for the purpose.

The bore of suction pipes is in proportion to the size of pump barrels, and they are usually as follows:—

Bore of pump barrels in inches	2½	3	3½	4	4½	5	6
Bore of suction pipes "	1½	2	2½	2½	3	3½	4

Lift pumps for all depths up to 25 feet are illustrated by Figs. 331 to 359.

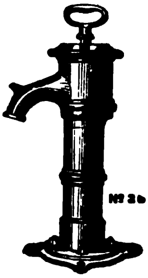

Fig. 331.

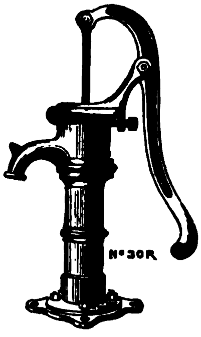

Fig. 332.

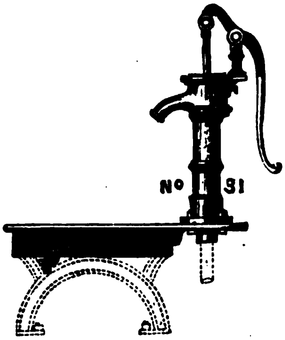

Fig. 333.

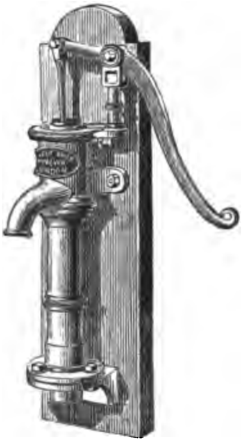

Fig. 334.

LIFT PUMPS FOR DEEP WELLS. Fig. 331 (No. 30) is a lift pump with bow handle, and being very light and portable, it can be used for a variety of purposes. The barrel is 2½" diameter, and the height 16", bored and tapped to suit 1¼" wrought-iron tube. Price 15*s.*

Fig. 332 (No. 30 R) is similar to Fig. 331, but fitted with reversible cap; the handle is of the usual type. This pump is manufactured in two sizes, viz.:—

Diameter of barrel in inches	2	2½
" wrought-iron suction tube in inches	1	1¼
Height under spout in inches	14½	16
Price	£0 15 0	£0 18 0

Fig. 333 (No. 31), known as the "Sovereign," or universal pump, is similar in appearance, and is well suited for cottages, conservatories, or any place where only a moderate supply of water is required. The barrel is 2½" diameter, bored and tapped for 1¼" wrought-iron tube, fitted with reversible cap and handle, and is made in four different heights, viz.:—

13" high under spout	Price £1 4 0 each.
19" „ „	„ 1 6 6 „
22" „ „	„ 1 7 6 „
25" „ „	„ 1 9 0 „

Fig. 333 (No. 131) also shows an improved independent portable sink, or water and pump-stand, especially adapted to carry the smaller sizes of pumps, No. 31; it is fitted with air trap, for 1½" iron tube to conduct waste water to the drain; is 30" long, 18" wide, and stands 21" high outside—18*s*.

No. 31 B is similar to Fig. 333. The barrel is 2½" diameter, fitted with reversible cap and handle, with bracket and lugs for attaching to a wood plank or to a wall, and is bored and tapped for 1¼" tube—£1 7*s*.

Fig. 334 (No. 31 B P) is a No. 31 B pump fitted on a plank, ready for bolting to a wall—£1 13*s*.

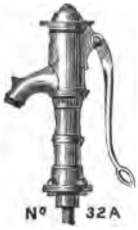

Fig. 335.

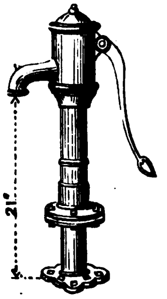

Fig. 336.

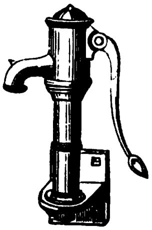

Fig. 337.

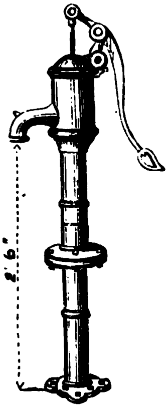

Fig. 338.

Fig. 335 (No. 32 A) is a 2½" pump, 24" high and 13" under spout, fitted with tail piece, suitable for 1½" wrought-iron tube; the handle is enclosed in the pump head, and is therefore not liable to be broken—£1 7*s*.

Fig. 336 (No. 32 A A) is the same type of pump as Fig. 335, but stands 30" high and is 20" under the spout; the tail piece is suitable for 1½" cast-iron flanged pipe or 1½" wrought-iron tube—£1 7*s*.

Fig. 337 (No. 32 B) is similar to Fig, 335, but is fitted with bracket and lugs for attaching to a wall; suitable for 1½" wrought-iron suction tube—£1 10*s*.

No. 32 B P is Fig. 337, mounted on a strong wood plank—£1 15*s*.

No. 32 C is similar to 32 A A, only made to stand higher, being 40" high and 30" under spout—£1 10*s*.

No. 33 D D is a 2½" cottage pump 24" high, 13" under spout, fitted with reversible cap and handle, bored and tapped to suit 1½" wrought-iron tube, and except in height is similar to No. 33 X X (Fig. 338)—£1 10*s*.

No. 33 X is similar to 33 D D, but 30" high and 20" under spout; mounted on tail piece, suited for either 1½" C. I. flanged suction pipe or 1½" wrought-iron tube—£1 10*s*.

Fig. 338 (No. 33 X X) is the same kind of pump, mounted on tail piece; suited for either 1½" flanged pipe or 1¼" wrought-iron tube—£1 13*s*.

Fig. 339 (No. 318) is a 3″ pump standing 30″ high, 18″ under spout, and is fitted with reversible cap and handle, and bored and tapped to suit 1½″ wrought-iron tube—£1 13*s.*

No. 318 B is similar to Fig. 339, but fitted with bracket and lugs for attaching to a wall or wood plank—£1 16*s.*

No. 318 B P is the same kind of pump as Fig. 339, fixed on to wood plank—£2 5*s.*

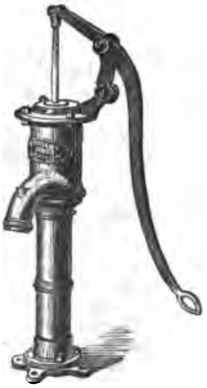

Fig. 339.

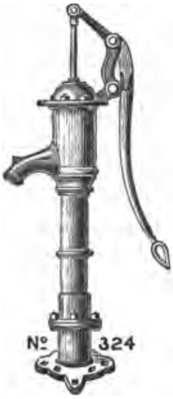

Fig. 340.

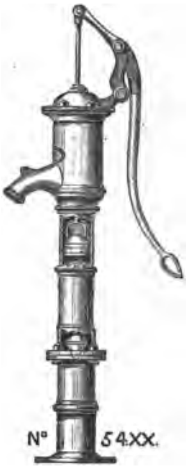

Fig. 341.

Fig. 340 (No. 324) is of the same type as Fig. 339, only 24″ under spout, and mounted on tail piece: bored and tapped for 1½″ W. I. tube, or suitable for 1½″ or 2″ flanged suction pipe—£1 16*s.*

No. 330 resembles Fig. 340, but stands 42″ high and is 30″ under spout · suitable for either 1½″ or 2″ flanged suction pipe or 1½″ wrought-iron tube—£1 18*s.*

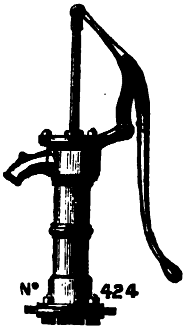

Fig. 342.

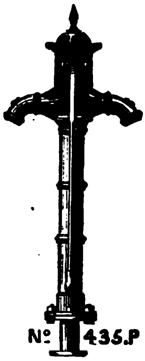

Fig. 343.

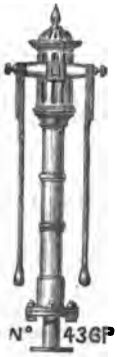

Fig. 344.

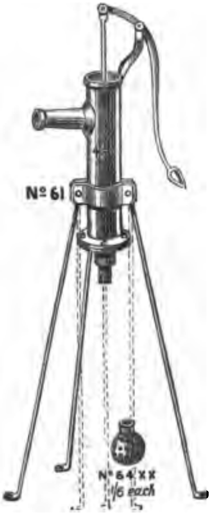

Fig. 345.

Fig, 341 (No. 54 XX) is a strong useful yard pump, with 3½″ barrel, 44″ high, 36″ under spout fitted with reversible cap and handle, and standard pipe to suit 2½″ flanged pipe, or for 2″ wrought-iron tube—£2 10*s.* 6*d.*

Fig. 342 (No. 424) has a 4½" barrel, is 24" high, and fitted with wrought-iron handle, and is tapped for 2" wrought-iron suction tube; suitable for fixing on liquid manure carts, &c.—£3 3*s*.

This pump can be made with curved spout (as shown in engraving) or straight spout and fitted on bracket pedestal, without extra charge.

Fig. 343 (No. 435 P) is a 3½" fluted pump, 4' 2" high, 3' under spout with bored barrel and two spouts, fitted with wrought-iron handle and with 2½" tail piece for flanged suction pipe—£3 6*s*.

Fig. 344 (No. 436 P) has double handles and gear, 4" bored working barrel, and is fitted with 2½" tail piece for flanged suction pipe—£5 14*s*.

Fig. 345 (No. 61) is a 4½" wrought-iron galvanized pump for liquid manure, and is fitted on wrought-iron tripod portable legs and with connecting piece, to which 2" iron suction tube or india-rubber hose may be attached—£3 3*s*.

No. 61 G is a 6" strong galvanized iron liquid manure pump, with barrel 36" long, fitted with tubular legs, stands 72" under spout, and is suitable for 3½" suction hose—£6 12*s*.

No. 62 is a similar pump to Fig. 345, with flanged base-plate and 2" connecting piece, but without tripod stand—£2 14*s*.

No. 63 B P is a similar pump to the foregoing, but fitted on a bracket pedestal, which admits of fixing it to a water cart, plank, or wall, and is suitable for 2" iron suction tube or I. R. hose may be attached—£2 17*s*.

Fig. 346 (No. 41) is a most serviceable pattern of pump, with fluted head and cap, stands 3 feet under spout, and is made to suit either cast-iron flanged or wrought-iron suction tubes. It is suitable for conservatories, stables, garden, yard and other purposes.

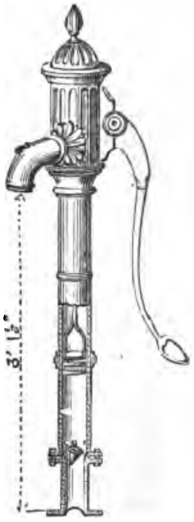

Fig. 346.

The following table gives the bore of suction pipes relatively to the bore of pump barrels, and may be considered correct with regard to Appleby's pumps generally:—

Bore of pump barrels, in.	2½	3	3½	4	4½	5	6
Bore of suction pipes „	1½	2	2½	2½	3	3½	4
Price as shown, each	£2 3 0	£2 10 6	£2 14 0	£3 0 0	£3 12 0	£4 10 0	..
Price 4 ft. under spout, each	2 6 3	2 13 6	2 17 0	3 3 0	3 15 6	4 16 0	..
Price with copper linings extra, each	0 7 9	0 9 0	0 10 3	0 12 6	0 15 0	1 4 0	2 2 0
Price extra with brass buckets and clack valves	0 5 0	0 7 0	0 9 0	0 10 6	0 12 0	0 15 0	1 10 0

These pumps can be made from 4 ft. to 6 ft. under the spout at an extra cost of from 6*s*. to 12*s*.

No. 466 is a similar pump to Fig. 346, 5 ft. 6 in. under spout, fitted with tail piece for flanged pipe, and is made in the following sizes:—

Bore of barrel in inches ..	3	3½	4	4½	5
Price	£3 3 0	£3 12 0	£4 1 0	£4 16 0	£5 14 0

The extra charge for fitting with copper linings is the same as for pumps, Fig. 346.

Fig. 347 (No. 34) is a strong cast-iron pump with 4" bored barrel, generally used for filling liquid manure carts. It stands 7' 6" under spout, and has strong wrought-iron handle and rod, and is fitted with 3" tail piece and extra large valve—£3 12*s*.

Fig. 348 (No. 36 P) is a strong pump, designed specially for street purposes, and will lift when worked at a moderate speed 2,200 gallons per hour. It stands 6 ft. high, is 4 ft. under spout, and is fitted with strong wrought-iron handle and 4" tail piece for flanged suction pipe—£6 12*s*.

No. 648 is in nearly all respects similar to Fig. 348, the exception being that it is provided with reversible cap and handle—£7 4*s*.

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Either of the two foregoing pumps can be made 5 or 6 ft. under spout at a slight increase on the prices given.

Fig. 349 (No. 478 P) is a 4″ fluted pump, with bored barrel, &c., fitted with extra strong lever or compound action, stands 7′ 8″ high, 6′ 6″ under spout; suitable for filling water carts, &c.—£5 8*s*.

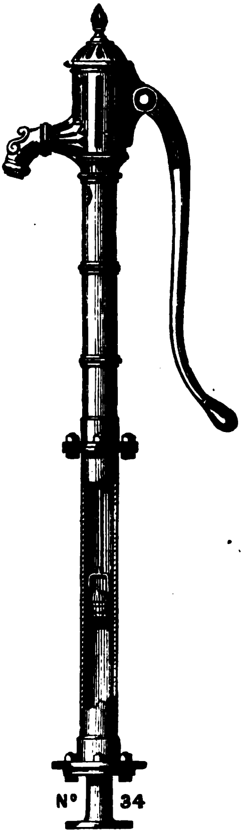


Fig. 347.

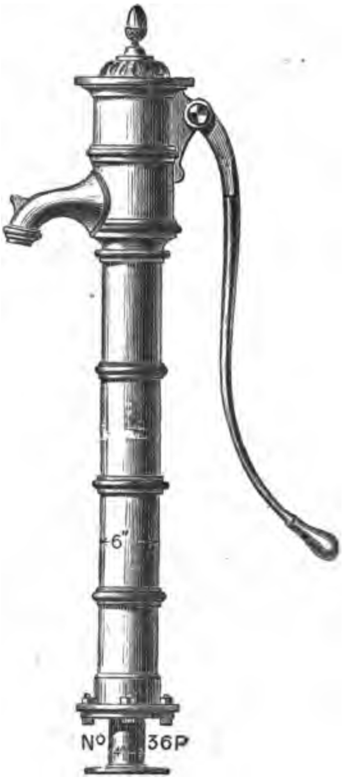


Fig. 348.

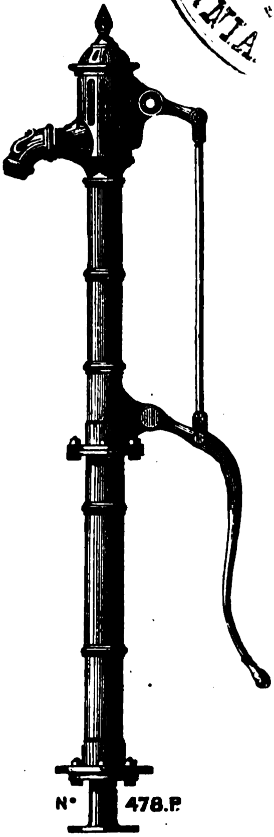


Fig. 349.

LIFT AND FORCE PUMPS FOR SHALLOW WELLS.—These pumps are fitted with turned rods, brass bushes, reversible caps and handles, and are suitable for wells not exceeding 25 feet in depth. Each pump is carefully tested before leaving the works.

Pumps fitted with air vessels and retaining valves, materially assist in forcing water to a considerable elevation, maintain a continuous flow, and relieve the strain in working.

Fig. 350 (No. 33 F) is a 2½″ pump, 24″ high, 14″ under spout, fitted with flanged base-plate and to suit 1½″ wrought-iron tube for suction and rising main—£2 10*s*. 6*d*.

This pump can be fitted with bracket and plank at an extra cost of 10*s*.

No. 33 V is a 2½″ pump, 40″ high, 30″ under elbow, and is fitted with retaining valve and dome cap to suit either 1½″ flanged pipe or iron tube for suction or rising main—£3 3*s*.

No. 33 VV is similar to Fig. 350, fitted with cast-iron air vessel and retaining valve, and made to suit 1½″ wrought-iron tube for suction and rising main—£3 12*s*.

Fig. 351 (No. 318 F) is a 3″ pump, 30″ high, 18″ under elbow, fitted with flanged base-plate, and suitable for 1½″ wrought-iron tube for suction and rising main—£2 17*s*.

Fig. 352 (No. 318 VV) is a similar pump to Fig. 351, fitted with cast-iron air vessel and retaining valve and flanged base-plate; suitable for 1½″ wrought-iron tube for suction and rising main—£3 12*s*.

Fig. 353 (No. 330 V) stands 42" high, 30" under elbow, is fitted with retaining valve and dome cap, and to suit either 1½" flanged pipe or wrought-iron tube for suction and rising main—£3 6s.

Fig. 354 (No. 337) is a 3" lift and force pump, fitted with strong iron fulcrum plate, bolted to plank 6' × 11" × 3"—£4 14s. 6*d*. If fitted with air vessel, extra—7*s*. 6*d*.

No. 58 F has a 3½" working barrel and is similar to Fig. 355, fitted with flanged base-plate, and made suitable for 2" iron tube for suction and rising main. This pump stands 30" high and 22" under branch—£3 6s.

No. 58 V has a 3½" working barrel, fitted with retaining valve and dome cap, stands 44" high and 36" under elbow. It is similar in appearance to Fig. 355, and made to suit 2" flanged suction pipe or iron tube—£3 18s.

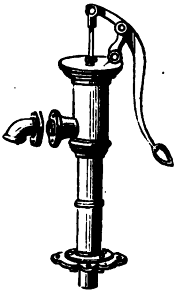


Fig. 350.

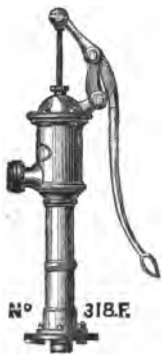


Fig. 351.

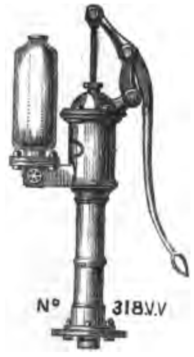


Fig. 352.

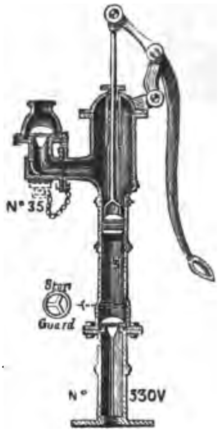


Fig. 353.

Fig. 355 (No. 58 VV) is a 3½" pump, 30" high, 22" under the elbow, fitted with air vessel, and retaining valve and flanged base-plate. It is made suitable for 2" iron tube and rising main—£4 4s.

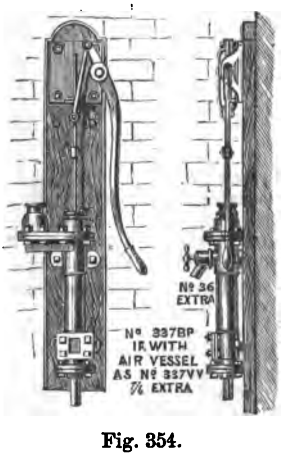


Fig. 354.

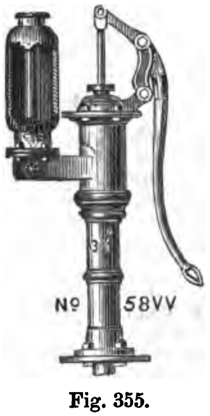


Fig. 355.

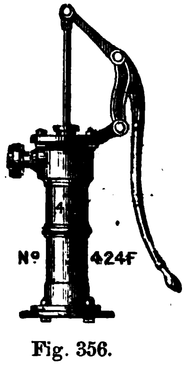


Fig. 356.

Fig. 356 (No. 424 F) is a 4½" lift and force pump, 24" high, fitted with wrought-iron handle, tail piece to suit 2" iron suction tube, and with branch nozzle for 2" delivery hose; can readily be fixed on barrow frames, &c., to irrigate lawns, gardens, &c.—£3 18s.

Fig. 357 (No. 436 VV) is fitted with gland and stuffing box, air vessel 18" × 7" and tail piece of the usual proportions, and stands 36" high.

Bore of pump barrels in inches	3	3½	4
Price, each	£4 0 0	£4 10 0	£5 0 0
Price if fitted for engine power	3 12 6	4 0 0	4 10 0

Fig. 358 (No. 59) is a 5" pump, fitted for engine power with gland and stuffing box, extra strong turned rod, and cotter joint to disconnect bucket, T pipe with retaining valve, globular cast-iron air vessel 12" inside diameter, stands 39" high and 31" under the branch, and is made suitable for 3" or 3½" flanged suction, and 2½" rising main pipes—£8 8s.

Fig. 359 (No. 636) is a 6" strong engine pump, fitted with gland and stuffing box, 1¼" turned rod and cap, with cotter to disconnect bucket, extra large elliptical air vessel with retaining valve; stands 48" high, 36" under the branch, and is made to suit 4" flanged rising main and suction pipe—£13 4s.

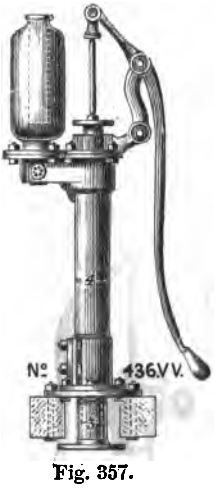


Fig. 357.

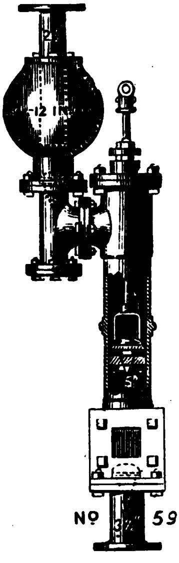


Fig. 358.

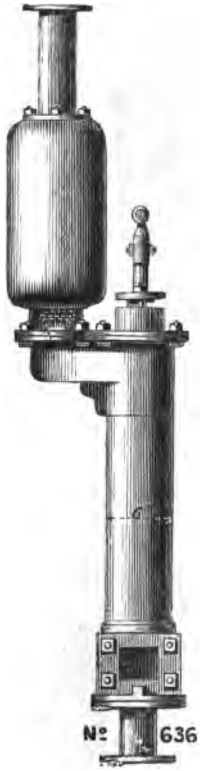


Fig. 359.

LIFT PUMPS FOR DEEP WELLS. The type illustrated, Fig. 360 (No. 100), is suitable for wells varying from 27 to 100 ft. in depth. The working barrel is 2 ft. 6 in. long, accurately bored and fitted, is placed about 20 ft. from the bottom of the well, and is supplied with 18 ft. 6 in. of flanged cast-iron suction pipe and strainer. The suction pipes are uniformly about one-third less in diameter than the bore of the working barrel. The main pipe is always ½ in. larger than the diameter of the working barrel, and the wood pump rods vary in size according to the depth of the well. The proportions given will ensure proper action if all the parts are properly fixed. The working barrels are made with or without bucket doors, but it is always desirable to have ready means of access to the working parts so that they may be easily examined or readjusted.

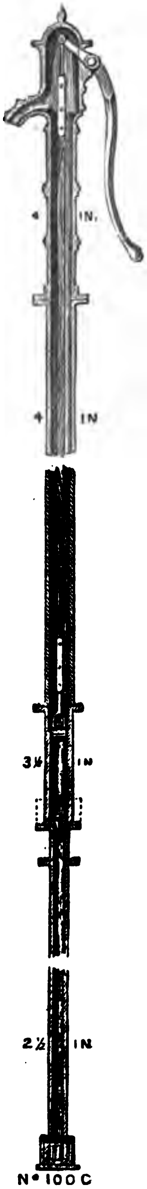


Fig. 360.

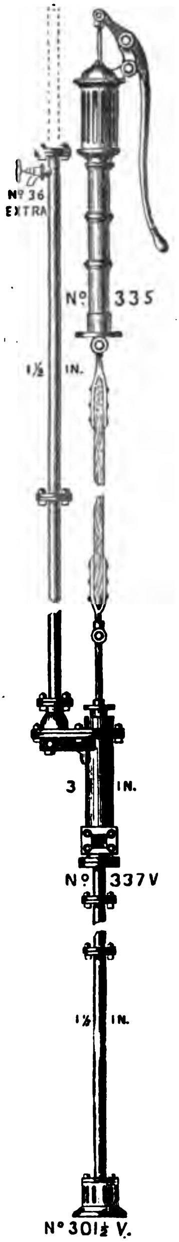


Fig. 361.

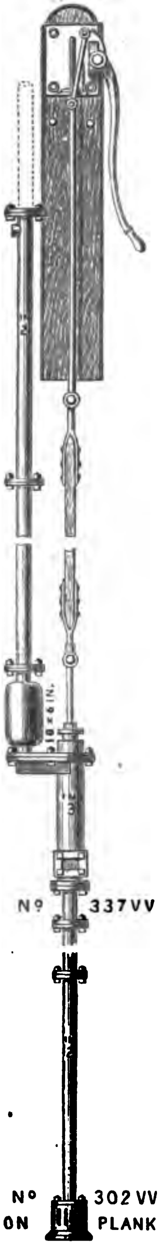


Fig. 362.

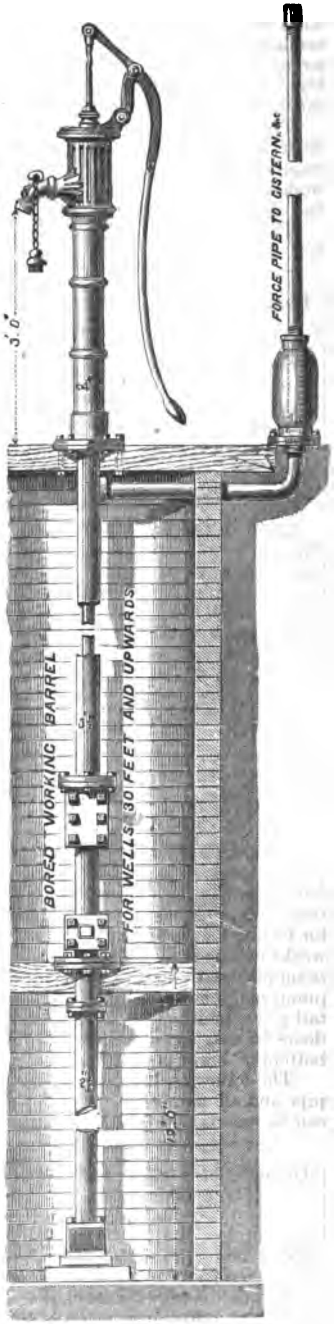


Fig. 363.

The pumps with 3 in. and 3½ in. working barrels are the best sizes for wells varying from 50 to 80 ft. deep, unless an exceptionally large supply of water is required, and the power is available to work larger barrels. The fluted pump-head or top is 36 in. high, and fitted with strong wrought-iron handle. For wells from 50 to 79 feet deep, the pump-head should be 4 ft. high; and for wells 80 to 100 ft. deep, it should be 5 to 6 ft. high, the extra charge for which ranges from 2*s*. 6*d*. to 12*s*.

The subjoined list gives the price of deep-well pumps of various diameters complete for 30 ft. deep, and including for each size 9 ft. of flanged main pipe, and wood rod, rendered impervious to the destructive action of the water, with iron forked strap at each end, bored working barrel, 18 ft. 6 in. of flanged suction pipe and strainer, and the necessary bolts, nuts, and elastic washers for all the pipe joints, ready for fixing.

The cost of pumps for greater depths can be easily ascertained by adding the extra cost per foot exceeding 30 ft. deep.

Diameter of working barrels in inches ..	2½	3	3½	4	4½
„ suction pipe „ ..	1½	2	2½	2½	3
Price, complete, for 30 ft. deep	£5 8 0	£6 0 0	£6 18 0	£7 16 0	£9 0 0
Price extra per foot, exceeding 30 ft., for main pipe and wood rods	0 2 6	0 3 0	0 3 6	0 3 9	0 4 0
Price extra if fitted with bucket door to working barrel, each	0 11 0	0 12 0	0 14 6	0 18 0	1 4 0
Price extra if working barrel is fitted with copper lining, each	0 8 0	0 9 0	0 10 6	0 13 0	0 15 0

LIFT AND FORCE PUMPS, FOR WELLS FROM 27 TO 70 FEET DEEP. Fig. 361 (No. 301½ V) is a pillar pump case 4 ft. high, fitted with vibrating motion, strong wrought-iron handle and rod, with connecting joints, pins, and 3 in. working barrel, 2 ft. 6 in. long, fitted with turned rod gland and stuffing-box, patent bucket and valves, elbow with retaining valve, or with air vessel, with clack door, &c.; and for 30 ft. deep includes 9 ft. of wood rod and iron forked straps, with connecting joint at each end, 18 ft. 6 in. of flanged suction pipe and strainer, 12 ft. of flanged rising main pipe, bolts, nuts, and elastic washers for all the pipe joints, ready for fixing.

Price, complete for 30 ft. deep (exclusive of patent tap)	£7 1 0
Price, extra per foot for pipe rod and fittings, if exceeding 30 ft. ..	0 1 4

Fig. 362 (No. 302 VV) is a similar pump except provided with fulcrum plate and plank for wall as shown.

Price complete for 30 ft. deep	£8 2 0
Price extra per foot for pipe rod and fittings, if exceeding 30 ft. ..	0 1 8

LIFT AND FORCE PUMPS FOR SHALLOW AND DEEP WELLS, Fig. 363 (No. 101). The pump-head stands 3 ft. under the spout, has an extra large and strong flange at the bottom for bolting to the foundation, and is fitted with strong wrought-iron handles and vibrating links, the nozzle of spout is screwed to take a brass plug, which is used when the pump is required for forcing and is attached thereto by a strong tinned chain as shown. The rod is turned and works in a metallic gland and stuffing box placed outside the cap, readily accessible, and the pump is supplied with flanged rising main pipe, ½ in. larger in diameter than the bore of the barrel, wood pump rod, rendered impervious to the destructive action of the water, bored working barrel; with tail piece, total length 3 ft., with bucket with sword joint, and brass coupling, clack valve, and doors for easy access to both bucket and valve, 18 ft. of flanged suction pipe and strainer at the bottom of lower pipe, 6 in. long.

The following list gives the price of these pumps complete, with 9 ft. of flanged rising main pipe and all accessories for a depth of 30 ft. 6 in. The extra cost of pumps for deeper wells can be ascertained from the additional cost per foot exceeding 30 feet deep.

Diameter of working barrel in inches ..	2½	3	3½	4
„ main pipe .. „ ..	3	3½	4	4½
„ standard head „ ..	3	3½	4	4½
„ suction pipe „ ..	1½	2	2½	3
Price complete for 30 ft. deep	£9 18 0	£10 10 0	£11 14 0	£12 18 0
„ extra per foot if exceeding 30ft. 6 in. for main pipe with wood rod	0 2 6	0 3 0	0 3 6	0 3 9
Price extra if working barrels are lined with copper	0 8 0	0 9 0	0 10 6	0 13 0

The whole of the pipes can be easily bolted together, and all the bolts, nuts, and elastic washers necessary for fixing the pump in the well are supplied and included in the prices given for each pump. The side branch pipe, retaining valve, and air vessel and vertical pipe shown in the engraving are not included, these being required to suit special purposes. If these pumps are made with flanged branch, and the flange fitted with screw plug ready for attaching wrought-iron force pipe at any time, the additional price is 5*s.* 6*d.*

Fig. 364 (No. 103) is a deep-well pump adapted for lifting purposes only, and discharging at the spout; the parts below the ground line are exactly similar to Fig. 363 (No. 101).

Diameter of working barrel in inches	3	3½	4
„ suction pipe „	2	2½	3
Price complete for 30 ft. 6 in. deep	£7 10 0	£8 14 0	£9 18 0
„ extra per foot if exceeding 30 ft. 6 in.	0 3 0	0 3 6	0 3 9
„ „ if working barrel is lined with copper ..	0 9 0	0 10 6	0 13 0

Fig. 365 (No. 104) is suitable for wells not exceeding 27 ft. 6 in. deep, and, if fitted with retaining valve, will force 50 or 60 ft.; the working barrel is bored, and the forcing pipe taken below the ground line as shown. The prices given below are for pump with working barrel below ground line, fitted with side branch, bucket and valves, but exclusive of suction and branch pipes.

Diameter of pump barrels in inches ..	2½	3	3½	4
Price	£7 4 0	£7 16 0	£8 8 0	£9 6 0

FITTINGS FOR DEEP-WELL PUMPS ONLY.

Fig.	No.	Bore of Pump Tops and Working Barrels. (In Diam.)	2½	3	3½	4	4½	5	6
			s. d.	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*
369	35	Pump tops or cases, with fluted heads and caps, unbored, fitted with strong wrought-iron handles, joints, pins, cotters, and piece rod for welding, 4 ft. 10 in. high, 3 ft. under spout, each	29 0	30 0	33 0	36 0	43 6	50 6	..
	35L	Pump tops or cases, and caps, fluted pattern 5 ft. 9 in. high, 4 ft. under spout. Fitted same as Fig. 369 (No. 35), each	..	33 0	36 0	39 0	47 0	55 6	..
	35XL	Pump tops or cases and caps, fluted pattern, 7 ft. 9 in. high, 6 ft. under spout. Fitted same as Fig. 369 (No. 35), each	..	..	..	50 6	57 0	66 0	..
370	36C	Pump tops or cases and caps, unbored, 6 ft. high 4 ft. under spout. Fitted same as Fig. 369 (No. 35), each	..	..	..	..	..	..	90 0
366	37	Working barrels, fitted with patent buckets and conical valves, clack doors and tail pieces, with elastic packings, bolts, nuts, and washers (30 in. long). Proved to a great pressure, each	25 0	30 0	36 0	42 0	48 0	60 0	..
371	38	Working barrels (improved), fitted with two doors for easy access to bucket, and conical valve, bucket rod fitted with brass coupling joint, &c., to detach bucket; in other respects same as Fig. 366 (No. 37) (36 in. long). Proved to a great pressure, each	36 0	42 0	50 6	60 0	72 0	84 0	..
367	39	Working barrels, bored, unfitted, with tapered clack seat (24 in. long) to suit valve (No. 42) each	11 0	13 0	15 0	18 0	..	..	..
368	40	Working barrels, bored, unfitted, with clack door, and tapered clack seat (24 in. long), each	18 0	21 0	25 0	28 0	..	..	..
	42B & 44B	Improved brass buckets and valves, extra on all fitted pumps or barrels, per set	5 0	7 0	9 0	10 6	12 0	15 0	30 0

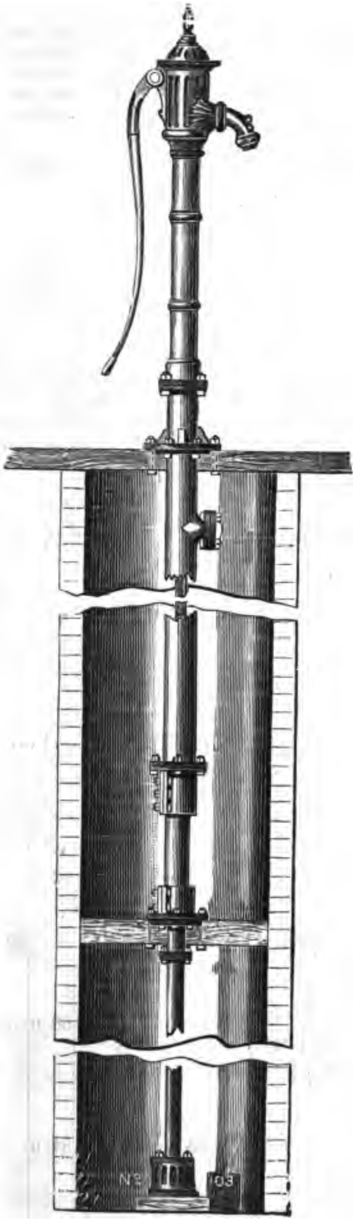


Fig. 364.

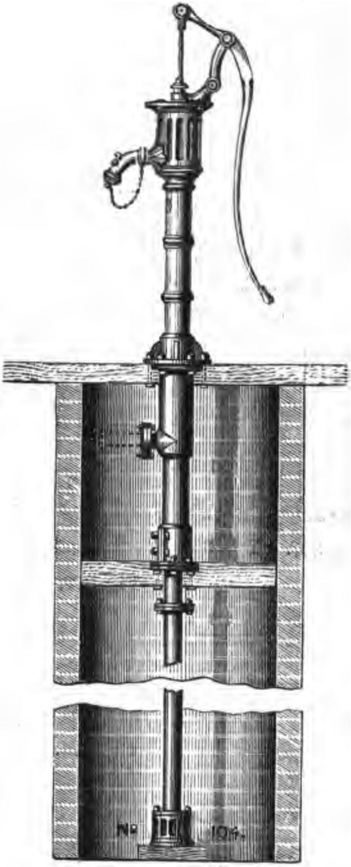


Fig. 365.

ANTI-FREEZING APPARATUS.—Any of the pumps, Figs. 331 to 365, described in the foregoing pages can be fitted with a simple arrangement of valves which allows the water to escape from the working barrel; this removes the inconvenience sometimes caused by the pump bursting during a severe frost. The apparatus has only recently been adapted to pumps with conical valves. The cost of this improvement is given below, and the advantage of it will be appreciated by those who have had pumps permanently injured by the effect of cold, but it is of course a useless outlay if the pumps are required in warm climates.

COST OF ANTI-FREEZING APPARATUS.

Diameter of pump in inches ..	2½	3	3½	4	5	6
Cost of apparatus	3/0	3/6	4/0	5/0	7/0	8/0

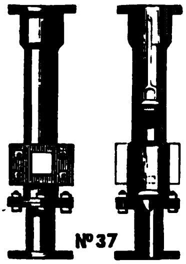


Fig. 366.

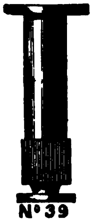


Fig. 367.

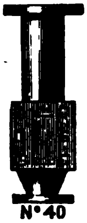


Fig. 368.

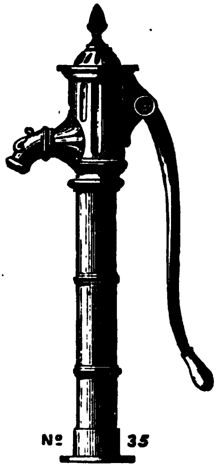


Fig. 369.

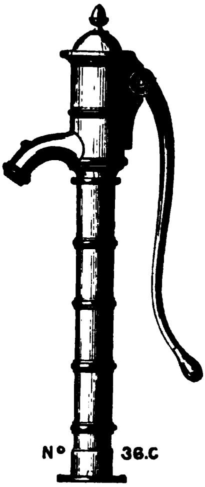


Fig. 370.

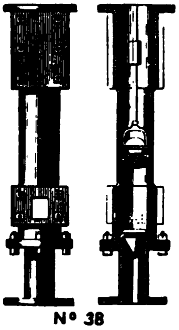


Fig. 371.

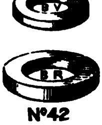
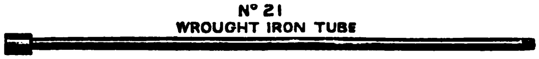


Fig. 372.

Fig. 373.



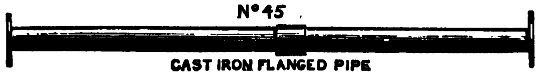


Fig. 374.

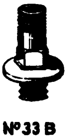


Fig. 375.

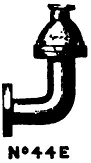


Fig. 376.

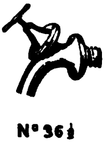
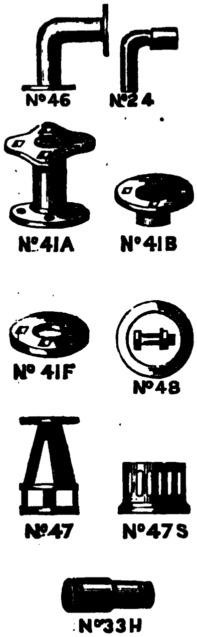
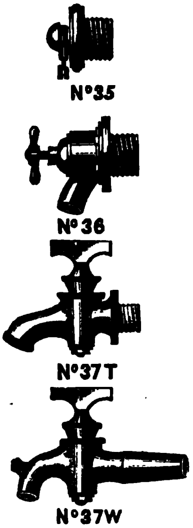


Fig. 377.



Figs. 378 to 386.



Figs. 387 to 390.

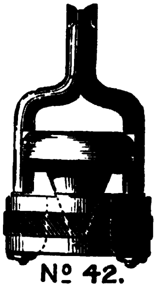


Fig. 391.

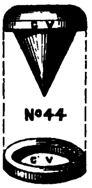
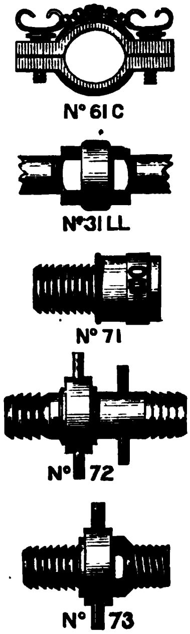


Fig. 392.



Figs. 393 to 397.

PUMP PIPES, SUNDRY FITTINGS, &c.

Fig.	No.	BORE OF PIPES, &c...	1	1¼	1½	2	2½	3	3½	4	Inch.
			s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	
374	45	Flanged pump pipes, proved to a high pressure .. .. .. (1½, 2, 2½, in. are made 6 ft. long; 3 in. and upwards are 6 ft. or 9 ft. long; irregular lengths charged extra.)	..	..	0 8	0 11	1 1	1 5	1 7	1 10	Per ft.
		3 ft. and under	..	..	2 3	3 0	3 6	4 9	5 3	6 0	Each.
378	46	Flanged elbows, 6 inches each way, from inside to face of flanges	..	..	3 0	3 6	4 3	5 0	5 9	6 6	”
383	48	Bolts, nuts, washers, and elastic rings to suit flanged pipe joints	..	..	0 8	0 9	0 10½	1 6	1 9	2 0	Pr. set.
		Bolts, nuts, and iron washers only	..	..	1 9	1 9	2 0	2 3	2 3	2 6	dozen.
373	21	Wrought-iron tubes	0 4½	0 6½	0 9	1 1½	..	..	..	..	Per ft.
379	24	Ditto bends	0 8	1 2	1 6	2 6	..	..	..	..	Each.
	33G	Tinned connecting pieces for soldering	..	1 3	1 6	2 0	..	..	..	..	”
		Untinned ditto, screwed at each end	..	1 0	1 3	1 6	...	..	..	..	”
375	33B	Brass connecting piece, tinned at one end for soldering, the other end screwed for iron	..	2 4	2 9	4 3	..	..	..	..	”
394	31LL	Patent union for iron and lead	2 3	3 6	5 0	8 0	..	..	..	..	”
387	35	Brass plug cap with chain, screwed to suit 1¼ or 1½ gas thread, 4s. 6d.	..	..	..	..	..	..	..	..	”
388	36	Improved iron water tap with brass screw, and screwed for iron gas thread	4 6	5 0	6 6	..	..	..	..	..	”
377	36½	Cock with screw and handle, screwed for iron, each	..	..	..	..	..	..	..	..	”
389	37T	Iron taps, galvanized, with strong patent metal plugs, screwed bottoms and tails for iron gas thread, each	4 6	9 0	11 0	..	..	..	..	..	”
390	37W	With tapered tails for driving	4 0	8 6	10 6	..	..	..	..	..	”
380	41A	Tail piece, with faced seat, to suit flanged pipe	..	..	2 6	3 0	3 6	4 0	5 0	..	”
382	41F	Extra flange, with countersunk hole for lead pipe joint, 1s. 4d. each	..	..	..	..	..	..	..	..	”
381	41B	Extra flanged boss, faced, bored, and tapped for iron tube, 3s. each	..	..	..	..	..	..	..	..	”
384	47	Windbore, 12 in. long, each	..	..	2 0	2 9	3 3	4 3	4 9	5 6	”
385	47S	Strainer, with fine meshes, each	..	..	3 0	3 3	3 6	4 0	5 0	5 6	”
	57XX or 64XX	Ditto, for wrought-iron tube or flexible hose, each	..	..	1 6	1 6	..	..	..	..	”
376	44E	Retaining valve, fitted to elbow, both ends to suit flanged pipe ..	..	..	8 6	10 0	12 6	..	..	..	”
	44F	Retaining valve, for vertical flanged pipes	..	..	7 6	8 6	10 6	..	..	..	”
	44T	Retaining valve, both ends to suit wrought-iron tube	..	..	7 6	8 6	10 6	..	..	..	”
		Large air vessel, as shown with Fig. 363 (No. 101), with retaining valve, to suit flanged pipes or wrought-iron tubes	..	25 0	25 0	25 0	..	..	..	..	”

Fig.	No.	SUNDRY PUMP FITTINGS—*Continued.*
	—61 c.	Iron screw clip joint for 1½" or 2" rubber hose, 4*s.* each.
395	—71.	Gutta-percha unions, with brass clip, for rubber hose, with socket and spigot ends. Subject to special quotation.
396	—72.	Best extra strong brass swivel hose screw. Subject to special quotation.
397	—73.	Best extra strong brass unions, squared and screwed to suit iron tube at one end. Subject to special quotation.
372	—42 B R.	Patent elastic rings for bucket shells (No. 42), from 4*d.* to 1*s.* 6*d.*
372	—42 B V.	Patent elastic washers for bucket valves (No. 42), from 2*d.* to 10*d.*
	—44 C V.	Patent elastic washers for clack valves (No. 44), from 3*d.* to 1*s.*

DOUBLE-ACTING FORCE AND LIFT PUMP.—These pumps are exceedingly compact, strong, simple in action, and all the working parts are easily accessible. The pumps are fitted with gridiron valves and india-rubber discs arranged so that by removing one bolt the valve can be taken out and replaced; the piston packings are double-cupped india-rubber, specially prepared for the purpose, so that the pumps may be used for any chemicals which do not affect that substance, and their working is rarely interrupted by great changes in temperature, or when they remain unused for a long period in hot or cold climates.

Being on the *double action* principle, viz—to raise water at both the up stroke and down stroke, one of these pumps is equal in capacity to two single-action pumps of the same diameter, whilst only one set of gear is required to work it. They are adapted to work by hand, or they are fitted to portable and ships' engines and cranes, and being proportioned throughout for lifting and forcing, they are available for all ordinary purposes, whilst in an emergency they may be used as FIRE ENGINES, or for SHIPS' PUMPS of the most powerful description.

For several different arrangements of this pump, see Figs. 291 to 296.

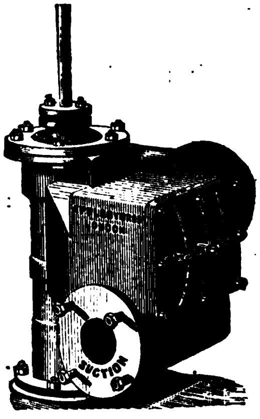


Fig. 398.

These pumps are also arranged to work horizontally, feet being provided on their side for bolting to a bracket or base-plate, and such a pump may be seen in Fig. 296 on the side of a portable engine. Prices as below:—

PRICES OF DOUBLE-ACTING PUMP, Fig. 398.

Diameter of pump in inches	3	4	6	8
Stroke " "	12	12	12	14
Gallons per hour at 40 strokes per minute	1300	2500	5200	11,500
Price of pump with iron barrel	£12 0 0	£13 0 0	£21 0 0	£30 0 0
" " brass-lined barrel ..	14 0 0	16 0 0	25 0 0	34 0 0
Extra for standards, slings and guides ..	2 0 0	3 0 0	4 0 0	5 0 0

DEEP-WELL LIFT AND FORCE PUMPS, Figs. 399, 400, and 401, are engravings of brass barrel pumps without doors for examination of valves, and available for wells not exceeding 70 feet in depth. The barrels are accurately bored, the valves and bucket are brass; each pump has a retaining valve in addition to the bucket valve. The annexed prices include glands, stuffing boxes, iron bow or cotter for attaching (copper) pump rod to well rods, but no suction or delivery pipes. Prices of the latter will be found on pages 148 to 154.

PRICES OF BRASS DEEP-WELL PUMPS, Figs. 399 to 401.

Diameter of barrels in inches	2½	3	3½	4	4½
Price of single-barrel pump, Fig. 399	£4 0	£5 0	£6 0	£7 0	£10 0
" double " " 400	8 10	10 10	12 10	14 0	20 0
" treble " " 401	14 10	16 5	19 10	22 0	27 0

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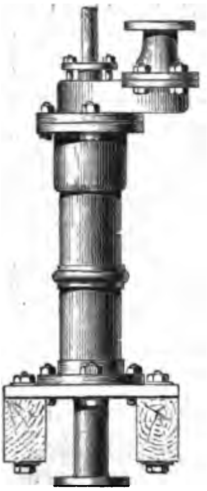

Fig. 399.

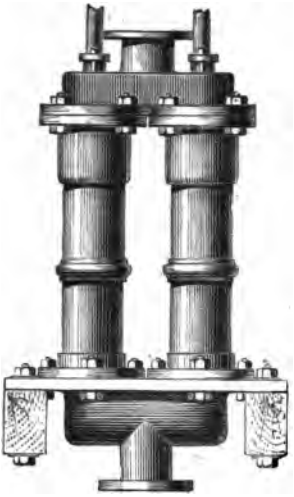

Fig. 400.

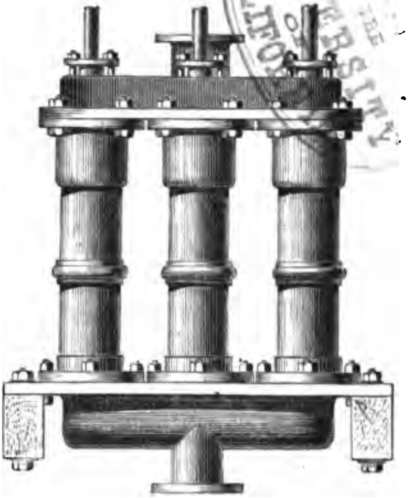

Fig. 401.

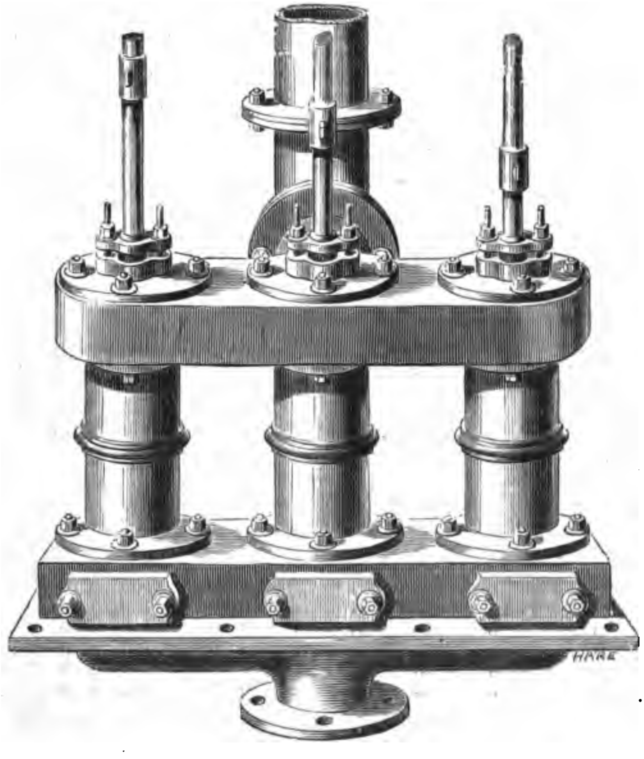

Fig. 402.

DEEP-WELL PUMPS, Fig. 402, are made with single, double or treble barrels, and are suitable for wells of any reasonable depth. All the barrels can be had either in brass or iron (prices of both will be found below), they are strengthened at the top and bottom by the flanges, and in the centre by an ornamental beading, and are accurately bored to the specified diameters. The bottom casting is arranged to carry all the foot valve seats, and has doors in it for the examination and repair of valves; it has a wide flange on each side to rest on the well stages, and bolt holes are provided in these for fixing the pumps. The suction pipes, if more than one, are all connected in the bottom casting, and run into one large central pipe, having a faced flange ready for connecting up to the suction pipes; the deliveries also run into one rising main, a retaining valve being usually provided at the bottom of this pipe carried in a casting with door for examination of valve. These pumps can be fitted with cast-iron frames for the top of well, with cranks, connecting-rods, slings and guides, and arranged to be driven by hand, horse, or steam power (see Figs. 298 and 299). The annexed prices include all necessary valves, buckets and rods, gun-metal glands, iron bows or cotters ready for attaching to the well rods, and suitable retaining or foot valve. For prices of pipes, &c., suitable for these pumps, see page 153.

PRICES OF DEEP-WELL PUMPS, Fig. 402.

Diameter of barrels in inches ..	2½	3	3½	4	5	6
Price of single iron barrel pump	£6 10	£7 5	£8 10	£10 0	£14 5	£17 10
" double "	10 10	11 10	13 10	14 15	21 10	30 0
" treble "	16 10	18 0	20 0	26 10	35 0	48 0
Price of single brass barrel pump	7 0	8 0	10 0	12 0	18 0	22 0
" double "	12 0	15 0	18 0	20 0	32 0	42 0
" treble "	18 0	22 0	25 0	32 0	46 0	70 0
Extra for cast-iron air vessel ..	1 5	1 10	2 10	3 10	5 0	6 10

If intended to pump hot liquor the prices are slightly increased.

PUMPS FOR PETROLEUM WELLS are usually from 2 to 3 in. diameter, and have a stroke of about 5 ft.; the barrels are made of brass and fitted with the necessary valves, and cast-iron heads, with covers and stuffing boxes; the bore pipes are screwed with flush joints, and tubular rods are supplied to reach from the surface to the pumps. The head-gear consists of a T or bob lever strengthened with wrought-iron tension bars and fitted with gudgeon and pedestals; wrought-iron connecting rod and guide, and wrought-iron joints for the sweep rods and balance weights.

Hitherto steam power has rarely been used for well-sinking; but experience shows that a very large saving is obtained both in time and cost of sinking if steam power is judiciously employed. Engines are now employed which can be used for the boring tools whilst the well is being sunk and for driving the oil pumps after the well is completed; if it be not necessary to drive the pumps by steam power, the engine can be employed for working any other kind of machinery, such as a pile-driver, hoist, &c. The cost of an engine complete with its own boiler is about £250. The cost of boring tools will be found on pp. 111 and 112. Pumps of this kind are required for use under such widely differing conditions that it would be impossible to fix a scale of prices which should be correct under all circumstances, but the following will serve as a basis on which the cost of such pumps may be estimated, and the prices will vary to only a comparatively limited extent, sufficient to cover the cost of such modifications as may be required to fulfil local conditions.

The following list includes the head-gear described above :—

PRICES OF PUMPS FOR PETROLEUM WELLS.

Internal diameter of pump barrels in inches	2	2½	3
Price for a depth of 200 feet .. .	£85 0 0	£100 0 0	£110 0 0
" " 300 "	105 0 0	120 0 0	135 0 0
" " 400 "	125 0 0	145 0 0	160 0 0
" " 500 "	140 0 0	175 0 0	185 0 0
" " 600 "	160 0 0	185 0 0	215 0 0
" " 700 "	175 0 0	205 0 0	240 0 0

A set of horse gear with pulley or intermediate gearing costs from £25 to £40, according to the depth of the well. Packing for shipment about 5 per cent.

STONEWARE FORCE PUMPS, Fig. 403. The working parts are composed entirely of stoneware, and consequently are admirably adapted for pumping acids, bleach, alkalies, vinegar, or any liquid which acts injuriously on metals. The valves, valve-seats, plunger, and other portions which have to fit, are accurately ground and fitted, and the pump may be arranged to be worked by hand or by steam power; the gland is usually packed with asbestos. In the engraving the joints of the pump are shown as flanged with ordinary bolts passing through them; the flanges are very thick and strong, but it is possible for a clumsy workman to break them by screwing the bolts up too tight. To avoid inconvenience from this cause the pumps are sometimes made with an improved form of connections, giving increased strength. This is done by replacing the flanges by collars much smaller in diameter than the flanges (consequently much stronger) and pulling them together by means of wrought-iron rings in halves, and bolts and nuts. The connection can be made with spigot ends for taking ordinary stoneware socket piping. The price of suction and delivery pipes is given below.

The subjoined prices include bolts, nuts, asbestos packing, keys, and india-rubber rings for connections.

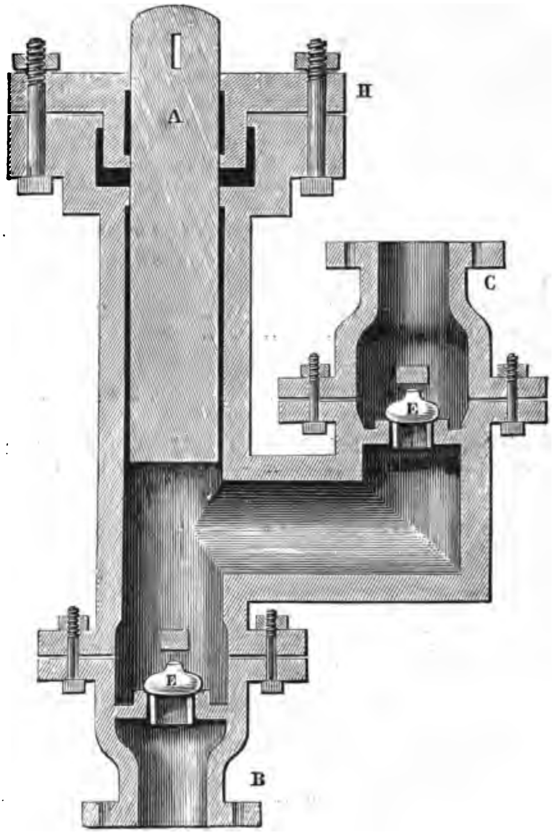

Fig. 403.

As these pumps are frequently used for raising thick or viscid liquids, the duty in gallons per hour is given for an assumed speed of 20 strokes per minute; but for pumping water or similar liquids, the speed of working may be much higher, in some cases nearly double. If the pump is worked by power, and is required to deliver variable quantities with a constant speed of driving shaft, the disc plate is fitted with a crank pin which can be adjusted to alter the stroke of the pump to the duty required from it; or, if more convenient, the speed of working may be reduced by cone pulleys.

PRICES OF IMPROVED STONEWARE PUMPS, Fig. 403.

Diameter of bore in inches	1½	2	3	4	6
Length of stroke in „	6	8	10	12½	15
Approximate gallons delivered per hour	44	100	290	680	1800
Price of pumps complete	£3 8	£4 7	£5 17 6	£7 8	£8 14

PRICES OF STONEWARE PIPES SUITABLE FOR PUMP, Fig. 403.

Diameter of bore in inches	1½	2	3	4
Price of 2 feet length	3/6	4/-	5/-	6/-

Packing costs about 7½ per cent.

PERREAUX'S PATENT PUMPS AND VALVES, Figs. 404 and 405. Fig. 404 shows a solid vulcanized india-rubber foot valve for ordinary atmospheric lifts, suitable for house, garden, street, or agricultural pumps. The valves are adapted for pumping ordinary water, but they are specially employed for those liquids which destroy metals. The action of the valves possesses some advantage over the ordinary lift or clack valves, their natural elasticity causing them to shut very quickly, so that there is little or no loss from slip on the return stroke; they are also very durable Two strengths of these valves are made. No. 1 are suitable for low lifts, and No. 2 for high lifts and pressures such as in force or feed pumps. An improved form of this valve is made with three lips, and the prices are rather higher than the subjoined.

PRICES OF PATENT INDIA-RUBBER FOOT VALVES, Fig. 404.

No. 1 *Strength.*

Diameter of pump in inches ..	2½	3	3½	4	4½	5	6	7	8
Price, each	3/6	5/-	7/6	10/6	14/-	18/-	24/-	36/-	48/-

No. 2 *Strength.*

Diameter of pump in inches	1¼	1½	1¾	2	2¼	2½	2¾	3	3¼	3½	3¾	4
Price, each	-/6	1/-	1/6	2/-	3/-	4/-	5/-	6/-	7/6	9/-	10/6	12/-

Fig. 405 shows the form of the bucket valve used in conjunction with the foot valve, Fig. 404. It is so designed that, in addition to being a bucket valve, it forms a cup to keep the bucket tight in the barrel. These valves should not fit too tightly in the barrel, and the best way of accurately determining the size of the barrel in reference to the valve is to caliper the cup of the valve half-way up and make the barrel correspond to the dimension so obtained. The mounting shown in the engraving consists of brass rings with bow carrying a boss at the top tapped for the bucket rod. Prices will be found for the valves only and for the bucket complete:—

PRICES OF BUCKETS AND INDIA-RUBBER VALVES, Fig. 405.

Diameter of pump in inches	2½	3	3½	4	5	6
Price of valve only	5/-	6/-	8/-	12/-	18/-	28/-
Price of bucket complete	10/-	12/-	15/-	20/-	30/-	45/-

GLASS BARREL PUMPS. The pump, Fig. 406, is used in breweries for raising hot wort, in gas works for ammoniacal liquor, in tan yards for tan liquor, in drainage works or farms for sewage, in paper mills for paper pulp and bleach, and in chemical works for strong acids, &c. It is also applicable to pump pure or dirty water. To suit the various circumstances under which it has to work, the mountings of the pump are made either of cast-iron, lead, or gun metal, whichever may be best suited to the liquor to be dealt with. The working barrel is made of the best plate glass, accurately bored out by machinery and highly polished, and owing to the hardness of the material its durability is very great. The mountings are of a neat pattern, arranged with flanges for coupling up to the suction and delivery pipes, and are held together by wrought-iron screwed bolts or stretchers, with double nuts at each end. The valves are solid india-rubber of the forms shown in Figs. 404 and 405. When it is intended to pump hot liquids it will be necessary to place the pump below the liquor, otherwise the steam evolved will prevent the creation of a vacuum in the cylinder. For thin liquids the pumps may be run at a high speed, but for dealing with thick fluids it is advisable to adopt a low speed.

The manner in which the foot and bucket valves are fixed is so clearly shown in the engravings, that further explanation is scarcely necessary; it may be observed, however, that in fixing the foot valve the bolts should not be screwed up too tightly on to the india-rubber flange, a water-tight joint being all that is required; any pressure beyond this is detrimental to the action of the valve, and has a tendency to keep the lips from closing. When the valve is fixed it should be examined to see that the lips close of themselves, otherwise an unnecessary quantity of water will be lost by slip on the return stroke of the bucket. It may also be noted that the orifice of the pipe immediately below the valve should not be larger than the area of the roundway valve. The corners of the flanges which fasten the valve should be rounded off so as not to cut the india-rubber. When the liquid is to be raised a considerable height it will be better to fix a retaining valve in the rising main.

PRICES OF PERREAUX'S PATENT PUMPS, Fig. 406.

Diameter of pump in inches	3	3½	4	5	6
Price with cast-iron mountings	£6	£8	£10	£12	£15
Price with lead "	£9	£12	£15	£18	£22 10
Price with gun-metal "	£12	£16	£20	£24	£30

PRICES OF GLASS PUMP BARRELS.

Diameter in inches	3	3½	4	5	6
Length in inches	12	14	16	17	18
Price	31/6	43/-	56/-	74/6	94/6

These pumps must be carefully packed, and the cost of this is 10 per cent.

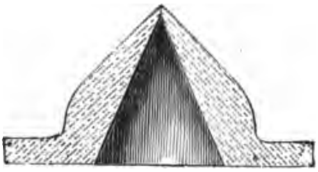

Fig. 404.

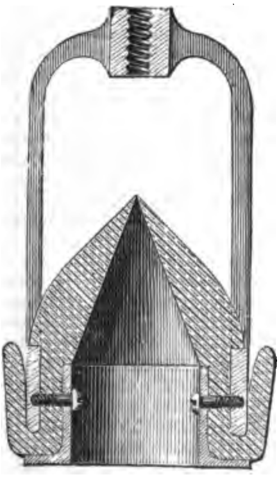

Fig. 405.

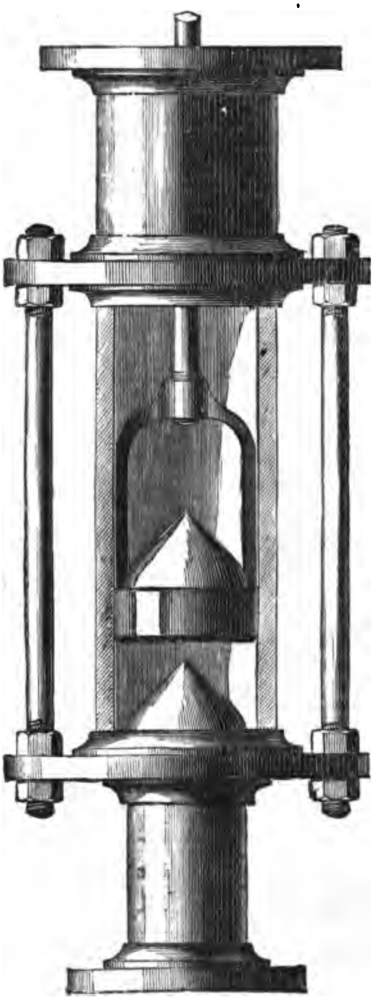

Fig. 406.

PLUNGER PUMP, Fig. 407, is available for a number of manufacturing purposes at gas works, &c., and is proportioned throughout for very heavy pressures or high lifts. These pumps are constructed of various metals, according to the liquids to be dealt with: thus they are made entirely of cast iron, or with cast-iron bored barrel and glazed and gun-metal valves and plunger, or entirely of gun-metal excepting bolts and nuts and connecting-rod, which are invariably wrought iron. The connecting-rods are sometimes made with sliding quills and cotters, so that the pump may be stopped without stopping the driving shaft. The pumps are usually worked by cranks or eccentrics on a line of shafting placed directly above them, or by a disc plate and crank pin on the end of a shaft: but they can be easily arranged to work by hand. The valves used are either ball valves, wing valves, or Appleby's patent conical valves, as may be preferred; whatever form of valve is adopted the valve boxes are provided with covers for examining or replacing the valves. The outlets of the pump are shown in the engraving as screwed for wrought-iron suction and delivery pipes; they can, however, be made for flanges if desired, and in fact in the larger sizes the latter form of outlet is invariably adopted. The pumps can either be mounted on a cast-iron base, with lugs for fixing to a floor or timber base, the cost being correspondingly above list prices, which are simply for the pump, as shown in the engraving, and do not include base, connecting-rod, or any suction or delivery pipes. The cost of suitable air vessels is given in the list, and it will sometimes be found advisable to have one on both suction and delivery pipes, also when the pump is to be used for very high lifts to place an extra retaining valve in the rising main. The speed at which the pump is driven should depend upon the nature of the liquid to be raised; if it is for thin fluids it may be run at 40 or even 50 strokes per minute, whilst for thick liquids 20 or 30 strokes per minute will be quite fast enough. If the pump is required to deliver variable quantities, this object can be attained by reducing or increasing the speed of the pump, but it is generally found more convenient to keep the speed uniform, and drive the pump, by a disc plate or crank arm with an adjustable crank pin, by means of which the stroke of the pump can be altered at pleasure.

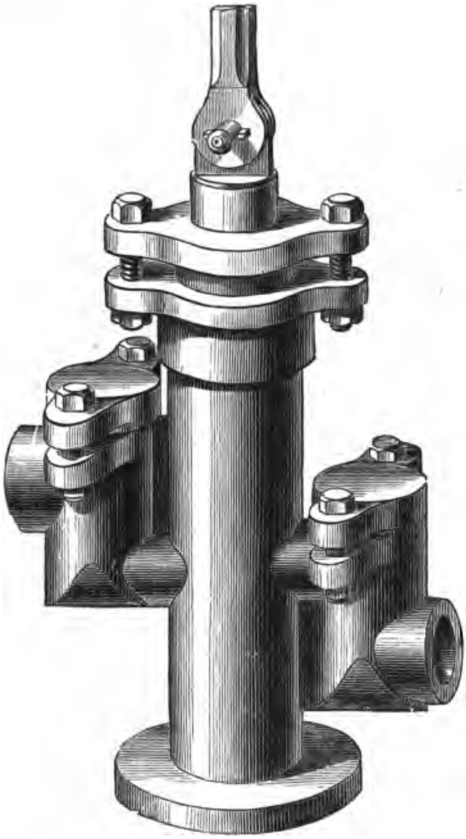

Fig. 407.

Pumps of this type are frequently used at gas works, arranged in sets of three in a similar manner to the double action pumps, Fig. 295; one of the pumps is then used for raising water, another ammoniacal liquor, and the third for tar.

Prices of Plunger Pump, Fig. 407.

Diameter of plunger in inches ..	1½	1¾	2	2¼	2½	3
Price, entirely of cast iron	£4 0	£4 10	£5 0	£5 10	£6 10	£8 10
„ with brass plunger and valves	£5 0	£5 10	£6 10	£7 10	£8 15	£10 0
„ entirely of gun metal ..	£6 10	£8 0	£9 0	£10 0	£11 10	£12 0
„ of suitable air vessel ..	£1 0	£1 5	£1 10	£1 15	£2 0	£2 0

Packing for shipment will cost about 6 per cent.

BORE-HOLE PUMP, Fig. 408, shows the now well-known bore pipe and pump used for obtaining water from a considerable depth without the loss of time and great expense involved in sinking a well in the ordinary manner.

The bore hole is made at a comparatively small cost to any depth up to about 300 feet below the surface, and when the water-bearing strata is reached, the bore is driven *through* the strata, instead of (as in the ordinary practice of well-sinking), *just down to the spring.* By this means a large supply of water is obtained, and generally the quality is superior to that taken from the surface of the strata.

When the bore hole has been made to the required depth, the pipes and pump are lowered into place, and the pump is then ready for work.

The suction pipe is of wrought iron, about 12 feet long, and the upper end is screwed to the lower end of a gun-metal pump barrel, the upper end of which is secured in a similar manner to the wrought-iron rising main pipe. The joints of this rising main pipe are flush inside and out, and the pump rods are in all cases the same length as the pipes, so that a length of pipe and rod can at any time be taken off or added without altering the position of the bucket in the pump barrel.

The pump rods are either screwed together or made with halving-joints and brass sockets, and the successive lengths of rod and main are connected together, and lowered until the required depth is reached.

If the water has to be forced above the surface, the top of the rising main is fitted with a stuffing box and elbow piece as shown, but if the water has to be delivered at the surface, an ordinary pump head is used. The top gear can, however, be fitted to work by hand, steam, or horse power, as required.

To estimate the cost of a complete set of bore pipes and pump it is necessary to know the probable depth at which the water will be reached, the height to which it is to be delivered, and the quantity required in a given time. The cost of putting down the bore pipe depends greatly on the geological formations to be passed through.

The cost of these pumps is about the same as petroleum pumps, which is given at page 102.

Illustrations and prices of the tools required for driving small bore pipes for shallow wells will be found on the following pages, together with a full description of the manner in which they are used; but when large sizes or great depths are necessary, boring tools of the kind illustrated, Fig. 413, will have to be resorted to. Estimates for complete sets of such tools for various depths of bore holes and prices of bore pipes are given in connection with the engravings referred to.

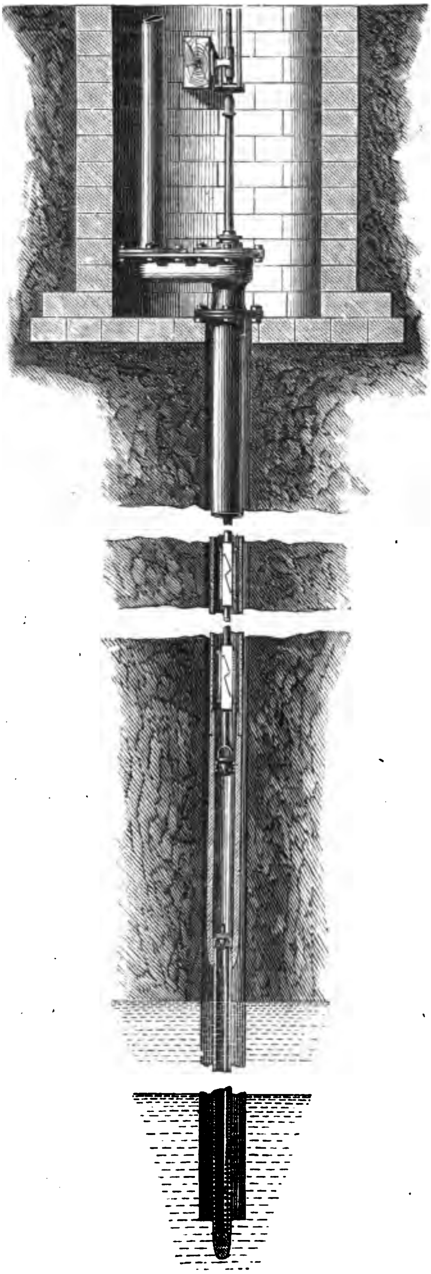

Fig. 408.

PATENT TUBE WELL AND DRIVING APPARATUS, Figs 409 to 412. By this system water can be obtained in all cases where the ordinary processes of well sinking or boring would be successful, and in many cases where those processes would fail—such, for instance, as in quicksand, &c. If a large supply of water is wanted, a number of tubes are driven into the ground till they reach the water-bearing strata, and are coupled together at the top and connected to a large pump, so that an almost unlimited supply can be obtained. The great ease and speed with which these wells are put into operation will recommend them where a temporary supply is required, or where time and first cost is an object of importance.

Pumps of this class were extremely useful in the Abyssinian War, the Darfur, and many other expeditions; indeed, taking into consideration how greatly the success of an expedition depends on sanitary conditions, and how much the latter depend upon the water supply, there can be no doubt as to the value of such appliances. The easy manner in which the pipes are driven and the pumps fixed, and the simplicity and non-liability to derangement of the pumps, render the system specially adapted for rough usage.

When the water does not rise to within 25 feet from the surface, the working barrel and foot valve must be fixed below the surface within 10 or 20 feet of the water; the arrangement of these parts are then similar to that illustrated by Fig. 408, but the upper part of the apparatus might remain as shown in Fig. 409. In some valleys the conformation of the water-bearing strata is such that water may be obtained by simply driving a tube down to the strata, and without the assistance of a pump, a valve being affixed to the top of the tube regulates the supply, this forms a very simple and inexpensive Artesian well.

DRIVING APPARATUS. On the next page will be found engravings illustrating the tools employed in fixing the tube wells. Fig. 410 shows the tube ready for driving, the sharp point below the perforations forming the suction strainer is resting on the ground; D is a clip bolted very tightly on the pipe A; C is a cast-iron ram or monkey, and by giving repeated blows with this monkey on the clip the tube is driven down till the clip reaches the ground; the clip is then moved higher up, and the operation repeated until the required depth is reached, additional lengths of pipe being screwed on from the top. The sharp point on the end of the pipe is made of tempered steel, which enables it to be driven through very hard strata. The pipe is steadied and kept upright by means of a tripod similar to that shown in Fig. 412. It frequently happens that a good deal of loose gravel and sand is met in the water-bearing strata; in such cases a special pump is used, called a cleansing pump, until the water pump is clear; or if the perforations at the bottom of the tube get choked, it is sometimes necessary to force a little water down the tube to clear them; the use of either the cleansing or force pump results in the formation of a small space or reservoir round the bottom of the tube, as shown in Fig. 411. In driving large tubes the reaction of the tubes under the action of the monkey is such that it is necessary to hold them down; this is effected by the apparatus shown in Fig. 412, which consists of a cross-head held in place on the top of the tube, to each end of this is fixed a species of accumulator, consisting of a top and bottom series of triangular plates bolted through

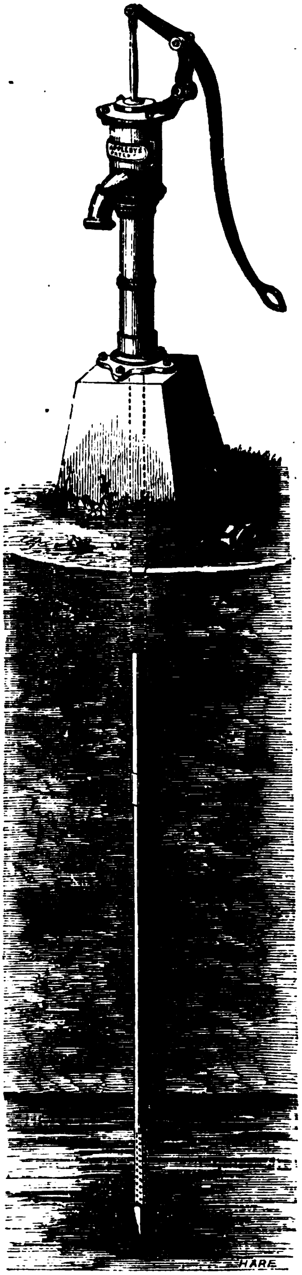

Fig. 409.

and kept about half an inch apart. These plates are connected by strong india-rubber bands. Chains pass from these accumulators to a crab, and a turn or so of the crab handle puts a steady pressure of 5 to 20 tons on the tube, as may be required. This pressure yields to the blow of the monkey and all rebound is avoided.

When no water is found or when the supply is no longer required, the tube may be easily withdrawn. It is stated that the tube fits so tightly in the ground that surface water or sewage cannot find its way down to the perforated end of the suction pipe.

To estimate the cost of any plant of this apparatus, differing from those in the subjoined list, it is necessary and useful to know at what depth it is expected to find water, what supply of water per hour is required, and what is the nature of the strata through which the tube will have to pass.

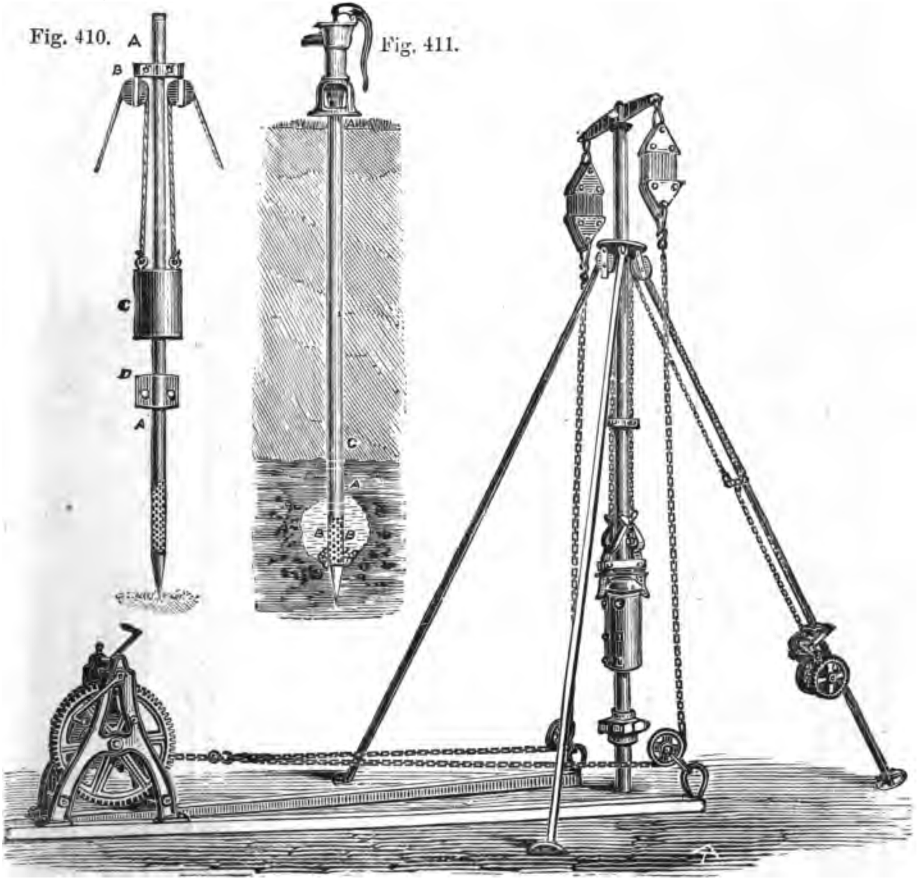

Fig. 410.

Fig. 411.

Fig. 412.

PRICES OF PATENT TUBE WELLS AND PUMPS, Figs. 409 to 412.

Internal diameter of tube well in inches ..	1½	2	3
Price of tube and pump, Fig. 409 or 411, for a depth of 30 feet	£7 0 0	£11 0 0	£20 0 0
Price of driving apparatus complete	£20 0 0	£32 0 0	£80 0 0
„ spare pipe per foot	3/6	5/6	10/6

Packing for shipment 6 per cent.

The cost of sand tubes is £2 5*s*. Brass force pumps, £2 15*s*. Disintegrator, £2 15*s*.

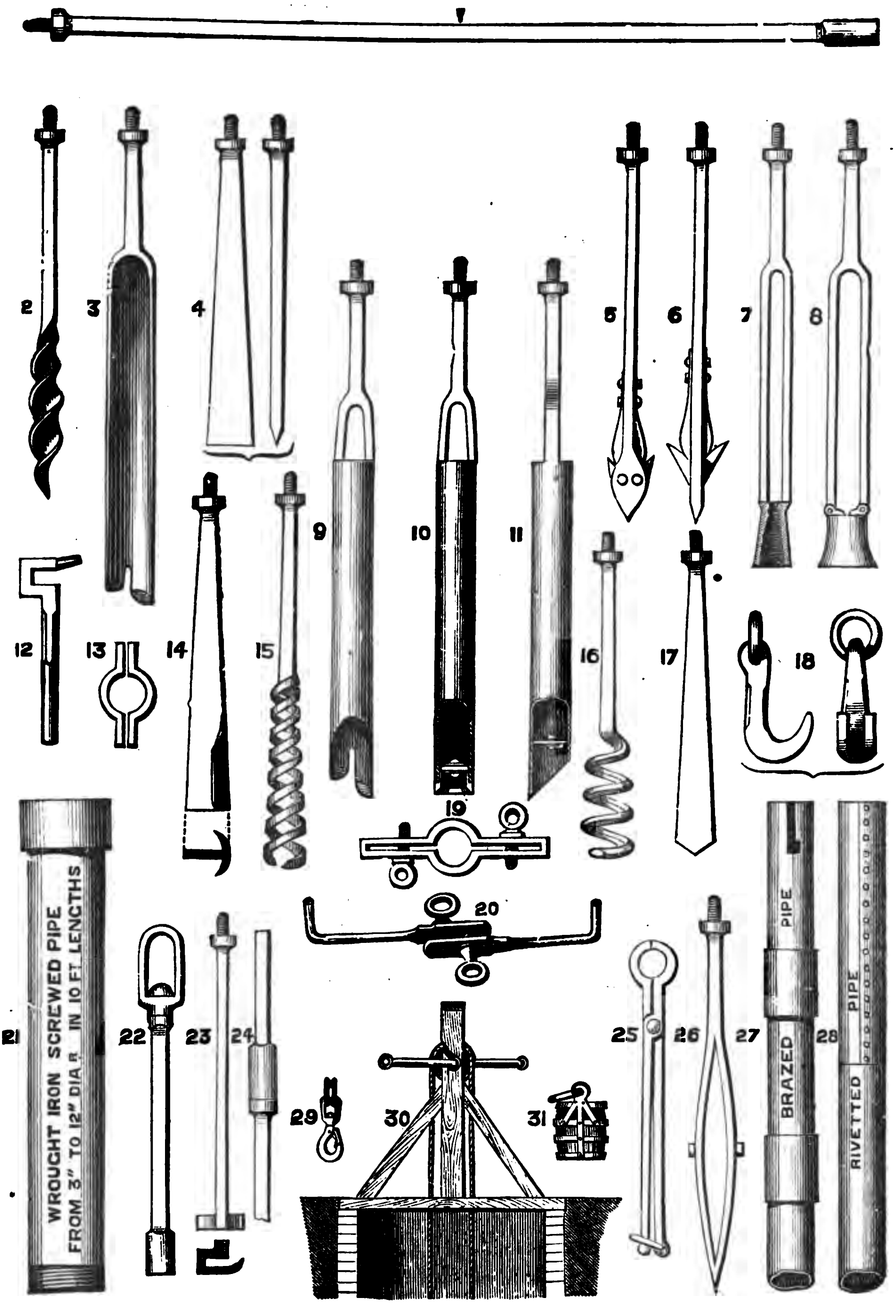
WROUGHT IRON SCREWED PIPE
FROM 3" TO 12" DIA R. IN 10 FT. LENGTHS
PIPE
BRAZED
PIPE
RIVETTED

Fig. 413.

BORING TOOLS, Fig. 413, for well sinking, testing ground, &c., consisting of—

1.—Well Rod, usual length 10 feet.
2.—Worm Auger.
3.—Open Auger, for clay.
4.—Flat Chisel, for stone or flint.
5.—Spring Dart, to draw faulty pipes from the bore hole.
6.— Ditto ditto, for smaller pipes.
7.—Bell Screw, for withdrawing broken rods.
8.—Bell Box, for ditto.
9.—Auger Nose Shell, with valve for loose soil or sand.
10.—Flat Nose Shell, for similar purposes.
11.—Shoe Nose Shell, for harder ground.
12.—Hand Dog, for screwing and unscrewing the rods.
13.—Pipe Clams, or Rests.
14.—T-Chisel, for flint or stone.
15.—Wad Hook, for withdrawing stones, &c., which may fall into the bore hole.
16.—Spiral Angular Worm for withdrawing broken rods.
17.—Diamond or Drill-pointed Chisel, for hard ground.
18.—Lifting Dog, for raising and lowering the rods.
19.—Long Pipe Clams or Rests.
20.—Tillers or Levers for turning the rods.
21.—Wrought-iron Screwed Well Bore Pipe.
22.—Short Rod, with Swivel Head.
23.—Crow's Foot for extracting the broken rods from bore hole.
24.—Pair of Well Rod Joints ready to shut up for greater lengths.
25.—Pipe Tongs or Heaters for making joints in pipes.
26.—T-piece or Pipe Dog for lowering the pipes.
27.—Brazed and Collared Pipe, with water-tight soldered joints.
28.—Common Rivetted Pipe, strong make.
29.—Spring Hook to be attached to Well Rope for raising tools, &c.
30.—Windlass complete, for Boring or Sinking.
31.—Strong Well Sinking Bucket.

The operation of deep well boring is frequently beset with many difficulties, and many kinds of tools have been designed to meet the varying circumstances under which they have to work; but those in general use are enumerated above and illustrated on the preceding page. To estimate closely the cost of a set of tools necessary to make any particular well, it is necessary to have as much information as possible on the following points: firstly, the depth and diameter of the bore hole—the hole is usually taper from top to bottom; secondly, the nature of the strata through which the tools will have to pass; thirdly, the purpose for which the bore hole is required—whether for Artesian well for supply of water or for testing the nature of the ground, for foundations of buildings, bridges, piers, &c., or for prospecting for minerals. The following estimates will, however, probably be useful in calculating the probable cost of any set of tools for use under ordinary conditions:—

No. 1.—Estimate for a set of trial boring tools for a depth of 40 feet:—

Eight 6-feet boring rods 1 inch square; three augers, one each 4. 3, and 2½ inch diameter; three chisels, one each 4, 3, and 2½ inch; one 3-inch shoe nose shell; one 2½ inch flat bottom ditto; one pair of tillers; two lifting dogs; two hand dogs; one auger board; and one auger clearer. The cost of this set of tools is £27 10*s*.

No. 2.—Estimate for a set of boring tools for a depth of 100 feet:—

Nine 10-feet boring rods 1 inch square; one 6 feet ditto; and one 5 feet ditto, with swivel head; four augers, one each 6, 5, 4, and 3 inch diameter; five chisels, one each 6, 5, 4, 3, and 2½ inch; three shoe nose shells, one each 5, 4, and 3 inch; one flat bottom shell, 2½ inch; one pair of tillers, two lifting dogs, two hand dogs, one auger board, and one auger clearer. The cost of this set of tools is £51.

No. 3.—Estimate for a set of boring tools for 150 feet:—

With the same bottom tools as for No. 2 set, but with the addition of five 10-feet lengths to the rods. The price is £57.

No. 4.—Estimate for a set of boring tools for a depth of 200 feet:—

With the same bottom tools as No. 2 set, but with the necessary length of 1¼ square rods The price is £75.

No. 5.—Estimate for a set of boring tools for a depth of 300 feet:—

With the same bottom tools as No. 2 set, but with the necessary length of 1¼ square rods. The price is £92.

No. 6.—Estimate for a set of of boring tools for a depth of 500 feet:—

Ten 13-feet boring rods 1¼ inch square, with 1½ inch screw joints; twenty 10-feet rods

1½ inch square, with 1½ inch screw joints; twenty ditto 1¾ inch square, with 1¾ inch screw joints; two short rods, with swivel heads, one each 1½ and 1¾ inch; and one 10-feet reducing rod, from 1¾ to 1½ inch; five augers, one each 8¼, 7¼, 6¼, 5¼, and 4¼ inch; five shoe nose shells, 7¼, 6¼, 5¼, 4¼, and 3¼ inch; five flat chisels, one each 8¼, 7¼, 6¼, 5¼, and 4¼ inch; five T-chisels, one each 8¼, 7¼, 6¼, 5¼, and 4¼ inch; three lifting dogs, one each 1¾, 1½, and 1¼ inch; three hand dogs, one each 1¾, 1½, and 1¼ inch; two pairs of tillers or levers; one large snatch block; one crow's feet; one bell box; two worm augers; two auger boards; two auger clearers; one strong spring hook, with 30 feet of best white rope; twelve square male screws, six each 1¾ and 1½ inch; six spare tiller screws; and one spring dart. The cost of this set of tools is £245.

One set of ironwork for shear legs. Price £3 10*s*.

One strong single purchase iron-bound crab windlass, with barrel 4 feet 10 inches long, for deep boring, £45. Smaller windlasses from £10.

Four T-pieces for lowering pipes, one each 8, 7, 6, and 5 inch. Price £24.

No. 7.—Estimate for a set of boring tools for a depth of 600 feet:—

With the same bottom tools, &c., as for No. 6 set, but with the addition of ten 10-feet lengths of rods, five each 1¼ and 1½ inch, all with 1½ inch screw joints. Price £270.

Shear legs, windlass, T-pieces, clams, and pipe tongs same as in estimate No. 6.

No. 8.—Estimate for a set of boring tools for a depth of 600 feet:—

With all the tools and rods same as No. 7, but with the addition of two augers, two flat chisels, and two T-chisels, one each 12 and 10 inch; two shoe nose shells, one each 11 and 9 inch. These tools are often required for such great depths. Price £325.

The following list gives the prices of pipes suitable for casing the bore holes; the pipes are wrought-iron, and are usually made in 9 or 12 feet lengths.

PRICES OF WROUGHT-IRON BORE PIPES.

Outside diameter in inches ..	3	4	5	6	7	8	9	10	11	12
Thickness Bm, wire gauge ..	15	14	14	12	12	12	12	10	10	10
Price of best brazed and collared pipe per foot ..	4/3	5/5	6/6	7/6	8/9	10/-	11/-	12/6	13/6	18/6
Price of rivetted „ ..	3/4	4/6	5/9	7/-	8/2	9/4	10/6	13/6	15/6	17/3
Steel collars and shoes, each	12/-	14/-	17/6	23/-	32/-	46/-	63/6	81/0	98/-	110/-

Subjoined is a list of the prices of welded wrought-iron pipes, suitable for bore pipes or bore pumps (see Figs. 408 to 412), with screwed joints flush inside and out, in lengths of 10 feet.

PRICES OF WELDED WROUGHT-IRON BORE HOLE PIPES.

Outside diam. in inches	2½	2¾	3	3¼	3½	3¾	4	4¼	4½	5	5½	6	6½	7
Thickness Bm, wire gauge	11	11	11	10	10	10	9	9	9	8	7	7	7	7
Price per foot	1/4	1/5	1/7	1/11	2/1	2/2	2/7	2/11	3/1	4/1	5/-	5/9	5/9	7/7

If preferred, cast-iron bore pipes can be used, made with flush joints, wrought-iron collars, and countersunk screws, but they are heavier and more expensive. A special class of tool has to be employed for very deep bore holes when the bottom is approached. To jump a thousand feet of rod with the tool at the end of it, even though the rod should be partially counterbalanced, has a very disastrous effect on the joints, therefore special tools have been designed with a self-acting clutch, in such a manner that the tool only (not the rod with it) drops. Such tools have been successfully employed in the boring of very deep Artesian wells in Paris and its vicinity. The Artesian well at Grenelle, in Paris, which took eight years to complete, attained a depth of about 1,800 feet before reaching water, whilst some wells on the Continent have been bored even a thousand feet deeper, mostly of small diameters; but at Passy, after much difficulty, extending over a period of 6¾ years, and at a cost of forty thousand pounds, a well was driven reaching the water about 1,914 feet from the surface. The diameter at the bottom is 2 feet 4 inches. This well delivers 3,795,000 gallons of water a day. The tools used in this instance were of a very special nature: a heavy trepan, weighing about 36 cwts., and carrying a number of steel chisels on its face, was lifted by means of a beam engine and allowed to fall on the rock to be cut away.

An excellent machine for use with boring tools for prospecting for minerals or testing for water before undertaking larger borings, will be found on reference to Fig. 210, Section 2.

THE DOWNTON ROTARY SHIP'S PUMP OR FIRE ENGINE, Fig. 414, generally used for many years past by H. M. Navy and in the Merchant Service, is made principally of gun-metal. A treble crank works three buckets, rods, and slides, and the suction plate and "goose neck" are so arranged that water may be drawn from the sea or from any one of six compartments. The pump is supplied with a heavy fly-wheel and wrought-iron handles, as shown in the engraving, and may be driven by manual power or by a messenger chain from the steam winch or donkey engine.

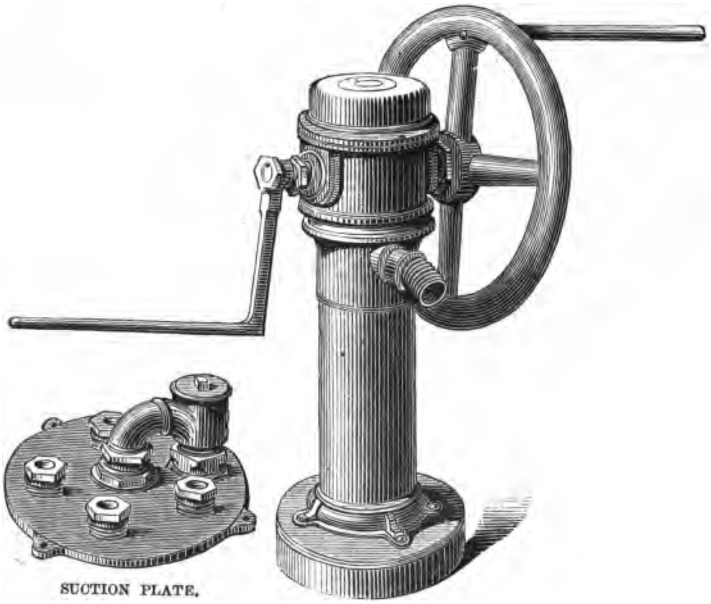
SUCTION PLATE.

Fig. 414.

PRICES OF DOWNTON ROTARY PUMPS, Fig. 414.

Diameter of pumps in inches	4½	5	5½	6	7
Delivers gallons per hour	2000	2500	3250	3900	5000
Price without suction plate	£22 0	£26 10	£30 0	£35 0	£40 0
„ of suction plate for 6 compartments	£5 15	£9 5	£9 5	£9 5	£9 5
Weight complete, about cwts. ..	3	3½	4	5	6
Diameter of suction and delivery hose in inches	1¾	1¾	2¼	2¼	2½

THE NAVY ROTARY PUMP is similar externally to Fig. 414, but improvements have been made in the internal construction, and as will be seen from the subjoined lists, the duty is higher than that of the Downton pump. The suction plate as usually supplied is arranged for drawing from the sea or from any of three compartments. The cost of a chain wheel for a messenger chain for either of the pumps is from £1 10s. to £2 10s.

PRICES OF THE NAVY ROTARY PUMP.

Diameter of pump in inches	3½	4½	5½	7
Delivers gallons per hour	2500	4000	6500	10,000
Price without suction plate	£22 0	£28 0	£38 0	£49 0
„ of suction plate for 3 compartments ..	£5 0	£6 5	£8 15	£16 5
Weight complete, about cwts.	2¾	3½	5	7
Diameter of suction in inches	2	2½	3	4
„ delivery hose „	1¾	2½	2½	3½

SHIP'S PUMP AND FIRE ENGINES, Fig. 415, have double gun-metal barrels, and are arranged with double lever handles, with cross bars for a number of men to work at. They are bolted down to a strong timber base, and, if desired, are protected by a wooden case, the ends of which fold up when not in use, and form a box to contain hose, implements, &c.; this insures the hose, &c., being at hand when required. The prices below include a branch and jet pipes, a rose jet, a wrench, and a suction strainer.

PRICES OF SHIPS' PUMPS, Fig. 415.

Number of men required to work pump ..	2	4	6	8	12	16
Price of pump without case	£7 10	£9	£11	£13	£18	£22
Price of pump with case	..	..	..	..	£20	£25

Packing for shipment usually costs about 5 per cent.

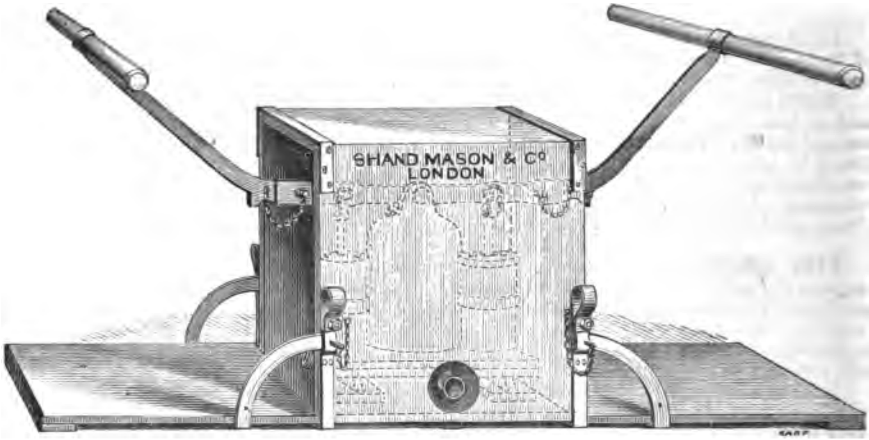

Fig. 415.

The following gear as spare parts for ships' pumps renders them more complete and reliable; and as the very existence of the ship may depend upon the pump being in thorough working order, it is in every sense desirable that such a supply of spare parts should be provided, as will ensure efficient action if the contingency should arise that the pumps have to be used. The prices in the following list are for gear suitable for 5 or 6 inch pumps, which are worked by from 12 to 16 men when doing full duty:—

1 Gun-metal elbow with screw for suction hose	£0	18	6
12 Suction hose washers	0	4	6
1 Extra copper branch pipe	0	16	0
3 Gun-metal nozzles	1	2	6
1 Spreading jet	0	16	0
1 Copper goose-neck	0	16	0
3 Spanners for bolts	0	10	0
2 Hooks for hauling pumps	0	4	0
12 Spare delivery hose washers	0	4	0
2 Spare cup leathers for pumps	0	12	0
1 Set of spare gland bolts	0	5	0
1 Set of spare bolts and nuts	0	5	0
1 Strong wood tool box (unless the pump casing forms the tool box), for containing and preserving the suction and delivery hose, tools, and spare gear. These boxes are made about 10 ft. by 1 ft. 8 in. by 9 in. deep, so as to contain 10 ft. lengths of suction hose without bending them; they are strongly framed together and well painted both inside and out	5	0	0

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The lengths in which delivery and suction hoses suitable for a ship's pumps are usually made are as follows:—

Leather suction hose	1 foot to	12 feet
Vulcanized india-rubber suction hose	1 do. „	30 do.
Leather delivery hose	1 do. „	60 do.
Vulcanized india-rubber delivery hose	1 do. „	60 do.
Patent woven delivery canvas hose	1 do. „	300 do.

A good-sized ship should carry the undernamed apparatus for use in case of fire, &c., the total cost of which varies from £45 to £50:—

1 Large-sized ship's pump, complete.
3 Lengths of leather or india-rubber suction hose, each 10 or 12 ft. long.
4 Lengths of leather or india-rubber delivery hose, each about 40 ft. long.
1 Length of canvas delivery hose, 100 ft. long.
1 Complete set of additional gear, as enumerated above.
1 Tool chest.

In all instances the leather suction and delivery hose are strongly recommended on account of their great durability; they will in the end be found reliable and the most economical in spite of their extra cost. They should be kept well oiled with a specially prepared oil.

Beside the three pumps last described there are many other forms applicable as ships' pumps, and on board ships of large tonnage it is usual to carry a steam fire engine in addition to the manual engine. The donkey pumps illustrated by Fig. 261 are employed for this purpose, and found to answer admirably. A direct-acting steam pump such as shown by Fig. 422, is also sometimes used. The steam pumps may be run at a very high speed, and will then deliver an enormous quantity of water, and can easily be designed to deliver to any required height. Prices and full particulars of these pumps will be found earlier in this Section.

FIRE ENGINES. The prevention of the destruction of property by fire is a subject which engages the attention of all civilised communities; and it may be doubted whether any kind of machinery is really more necessary than that designed for battling with fire. It is therefore not surprising that many official inquiries have been made in our own and other countries relative to the best systems of providing protection from fire, and the following information on the subject will probably be interesting.

In 1830 Braithwaite constructed the first land steam fire engine that was used in London; he made several which were exhibited at various public trials, but could not succeed in bringing them into general use.

The next attempt to apply steam for the working of fire engines was made for the London Fire Engine Establishment, which was not instituted till some time after Braithwaite's endeavour to introduce steam fire engines. In 1852 they had one of their large hand-worked floating fire engines altered so as to work by steam instead of manual power. The engine having been constructed by Tilley, the alterations were entrusted to and carried out by his successors, Shand, Mason & Co.

In the same year the first American land steam fire engine was constructed in New York.

The success which attended the above-mentioned alteration, and the great advantage which resulted from working by steam instead of manual power, induced the London Fire Engine Establishment to have an entirely new floating steam fire engine constructed for them, and in 1855 they invited tenders with designs. The experience gained by the above-mentioned alterations enabled the contractors to compete successfully on this occasion, and their design was adopted.

It consists of two distinct direct-acting engines and pumps placed horizontally one on each side of the boat, with a boiler to each, so arranged that each boiler will work either or both engines if required. The pumps are readily disconnected from the steam engine, which also works one of Appold's centrifugal pumps for propelling the vessel by the ejection of water from the sides, either towards the head or stern, by means of valves which work independent of each other on each side of the vessel. There are four outlets on the deck of the vessel to which the hose is attached. It will throw 2,000 gallons of water per minute to a height of 160 feet.

The same manufacturers have also constructed one for the Council of India, for use on the river Hooghley, at Calcutta, capable of delivering 3,000 gallons of water per minute. The engines, when disconnected from the pumps, work the screw propeller, with which the vessel attains a speed of 13 miles an hour. A full description with illustrations is given in the *Engineer* of 5th April, 1867.

In 1858 the same makers completed the first land steam fire engine which had been made since Braithwaite's, which was tried several times in public in London, and afterwards sold and sent to St. Petersburgh; they also constructed two more in the following year, one of which the London Fire Engine Establishment took on hire in 1860 for one year; this proved so advantageous that they purchased the fourth engine made by the same firm. This, with one of the two made in 1859, were the only land steam fire engines at the great fire in Tooley-Street in 1861.

At the Great Exhibition, 1862, there was a steam fire engine exhibited by a manufacturer in New York, which was worked publicly at Messrs. Hodge's Distillery at Lambeth. Messrs. Merryweather & Son placed their first steam fire engine in the Exhibition in 1862, which, like the one exhibited by Shand & Mason, was not in time for the opening, and consequently neither of these were eligible to compete for prizes.

The last inquiry on fire engines was conducted under the auspices of a Parliamentary committee, and some interesting and important facts were elicited from experiments made at the South Essex Waterworks on June 2th, 1877. It had been suggested that the Metropolitan District should be supplied with fixed hydrants to enable fires to be extinguished by affixing hose to these hydrants playing directly on the flames without the intervention of fire engines; the experiments were carried out to determine how far the pressure in the water mains was suitable for this system. The series of elaborate and conclusive experiments then made showed that in overcoming the friction due to driving 600 gallons per minute through 220 yards of 4-inch pipe, the pressure required was equal to a head of 225 feet. To further deliver these 600 gallons through 4 jets, each with 200 feet of hose, another 55 feet head would be required; and to throw the water a height of 50 feet from the jets required a further head of 80 feet. Therefore to deliver those quantities above-named through the lengths of pipe and hose would require no less a head than 355 feet; and it is needless to say that such a pressure is not at present obtainable in London. It is true that 220 yards is a great length of pipe for so large a quantity of water, and that with a larger and shorter pipe a much less pressure would be required. Nevertheless, when we consider that if high pressure were introduced in the Metropolis, all the existing house pipes and fittings would have to be replaced or strengthened at a probable cost of about four millions sterling, in addition to the cost of street hydrants estimated at three-quarters of a million, it is probable that it will be a long time before fire engines are superseded by hydrants.

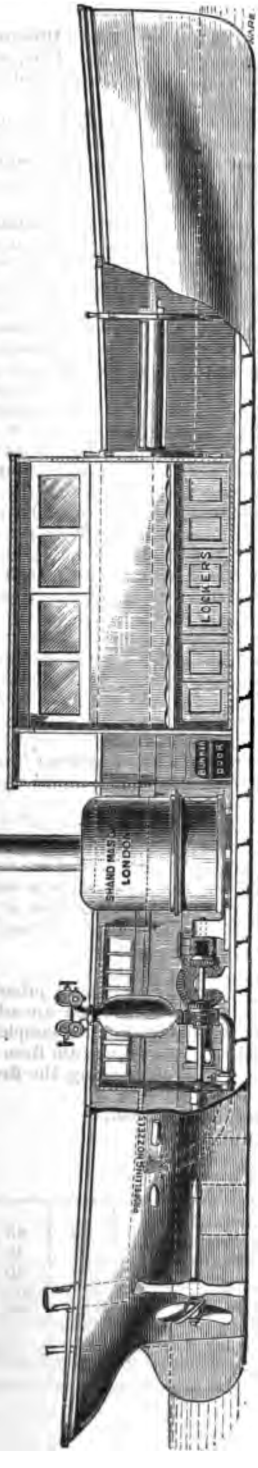
FLOATING FIRE ENGINES are invaluable in ports, docks, &c., or wherever warehouses and other premises are in proximity to water, whether self-propelling or placed in small vessels to be moved about by steam tugs; the former, although more expensive are more reliable, and therefore preferable. Fire engines alone, without boilers, may be and frequently are fitted on board steam tugs, ferry boats, &c., the steam from the propelling engine boiler rendering them immediately available in case of fire. An engine suitable for these conditions is shown in Fig. 422. In Section 1, Fig. 28 shows a steam tug fitted with a direct-acting steam fire engine, which can also be employed for supplying ships with fresh water, a large tank being formed in one of the bulkheads of the boat for the storage of fresh water. Steam tugs are also fitted with force pumps driven direct from the propeller engine; but as the propeller has to be disengaged before the pump can be started, this arrangement is less desirable than the separate fire engine complete with its own steam cylinder. In some countries, where the winter is so severe that the rivers are frozen for two or three months, it may be found economical to have a complete land fire engine which can be placed on a tug or barge during the summer and used on land throughout the winter.

SELF-PROPELLER FLOATING STEAM FIRE ENGINE. The subjoined prices refer to engines of a more powerful type than that shown in Figs. 416 and 417, and are adapted for general use as tug boats. They are fitted with two distinct engines, one coupled to the propeller and the other actuating the fire engine, but both supplied with steam from the same boiler. This arrangement enables the vessel to be propelled without stopping the fire engine, which is sometimes necessary, or at any rate convenient at fires.

The prices include every requisite excepting suction and delivery hose.

PRICES OF FLOATING FIRE ENGINES.

Approximate length of vessel	80	70	60	50	45	43
„ width „	14	13½	13	11	9	8
Indicated horse-power	200	135	90	60	40	27
Gallons discharged per minute	2250	1500	1001	670	450	300
Height of jet in feet	230	220	200	185	170	150
Diameter of jet if only one is used, in inches ..	2¾	2¼	1½	1½	1¼	1
Price complete	£5000	£3500	£2750	£2250	£1980	£1650



Figs. 416.

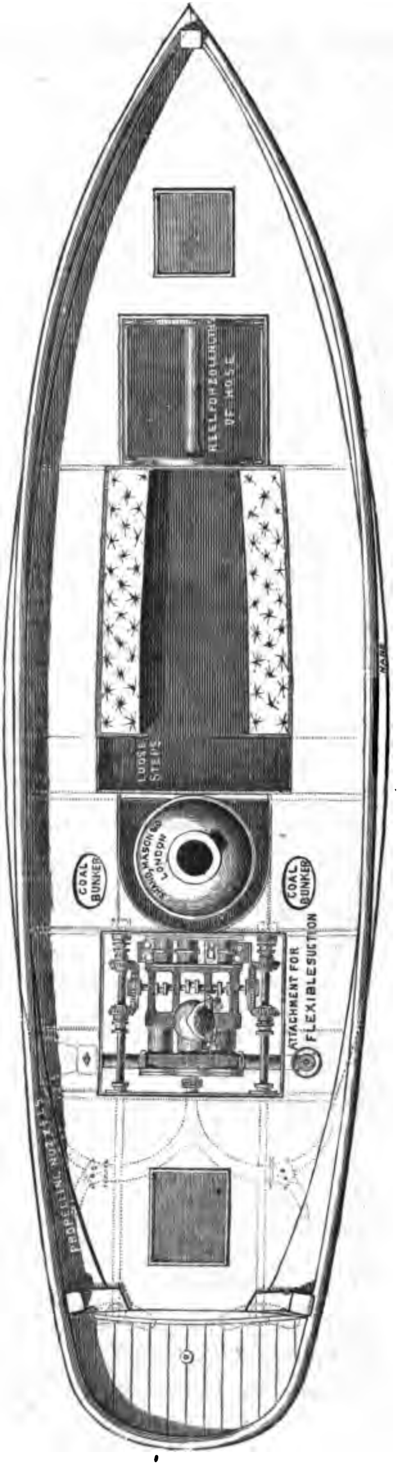


Fig. 417.

LIGHT-DRAUGHT HIGH-SPEED FLOATING STEAM FIRE ENGINE. Figs. 416 and 417 were specially designed for the Associated (London) Insurance Companies, for use in the shallow parts of the Thames. The vessel is 40 feet long by 10 feet wide, draught under 2 feet at stern and 1½ feet forward, and is of great strength, having two bulkheads and a continuous deck. There is a roomy cabin with lockers on each side, and hose reel for twenty 40-feet lengths of leather hose. The engine has three cylinders arranged to drive both the fire pump and the propellers. There are twin screw propellers driven by bevel gearing arranged with double pinions and clutches, so that the propellers can be made to revolve in either direction, and by this means the boat is very quickly steered. An arrangement is provided by which water jets from the fire pumps can be made to assist the propellers when it is desirable to travel at the maximum speed, this apparatus being under the control of the steersman. The pumps are capable of delivering 670 gallons per minute to a height of 185 feet. The price of this boat complete, with twenty 40-feet lengths of best copper rivetted leather hose and every requisite, is £2,170.

Iron floating fire engines can be shipped in sections marked and painted ready for re-erection.

As before stated, ordinary land fire engines can be adapted for fixing into boats, with the necessary connections for fixed and flexible suction-pipes, and the following list gives the prices and particulars of the engines.

PRICES OF FIRE ENGINES FOR TUGS OR BARGES.

Size number	1	2	3	4	5	6
Indicated horse-power	27	32	40	60	90	135
Diam. of jet when only one is used, in inches ..	1	1⅛	1¼	1½	1⅞	2¼
Height of jet in feet	150	160	170	185	200	220
Gallons delivered per minute	300	350	450	670	1000	1500
Price of single vertical engine	£375	£430	..	..	..	..
„ single horizontal engine	£340	..	£540	..	..	..
„ double horizontal engine	..	..	..	..	£990	..
„ treble vertical engine	..	..	£630	£800	£990	£1260

Cheaper engines can be obtained, but first cost is usually regarded as being of less importance than having engines complete and reliable in every respect.

If steam is taken from an existing boiler it will probably be at a low pressure; in that case an engine similar to Fig. 422, or a direct-acting engine like Figs. 267 or 268, would be suitable.

VERTICAL FIRE ENGINES of the type Fig. 418 are extensively used by the London and other Fire Brigades. There is only one steam and one water cylinder, and the construction is extremely simple in arrangement and detail. This engine was first publicly tested at the trials held at the Crystal Palace in June, 1863, when it delivered one-half more water in proportion to its weight than any other engine exhibited, and was awarded the first prize of £250. Since that date, prizes have been awarded for engines of this design at Middelburg (in Holland), Cologne, Dublin, Paris, Altona (Hamburg), and other places. The boiler is of the vertical tubular description, fitted with all necessary mountings, including safety valves, gauges, &c. Steam of good working pressure (about 100 lbs. per square inch) can be obtained from cold water in less than ten minutes from lighting the fire. The steam cylinder is directly over the pump, which is of the bucket and plunger type, and both are firmly attached to the boiler. The pistons of the steam engine and pump are directly connected by two rods, and the length of the stroke is limited by means of a crank shaft; after many years' experience this is found to be the best arrangement, as it not only prevents damage arising to the cylinder covers, but allows of the adoption of a very simple valve motion. The crank shaft carries a fly-wheel which enables the engine to be pulled round for oiling, &c., when it has not to be used for some time. The feed-pump is driven from the crank shaft. The whole engine is mounted on a strong wrought-frame, with forelocking gear, springs, four high wheels, pole and sway bars for a pair of horses, driving seat and foot board. The engine is free from all peculiarities with which engineers are not familiar, so that if anything requires adjustment or repair it can be done by any engineer, and a man of ordinary intelligence can work it after a few trials. The whole of the parts are readily accessible, and the hose and suction pipes are clear of all the machinery when in action. The engine will deliver through two lines of hose, which may be used separately or together by means of a valve so arranged that both outlets cannot be closed at the same time. As an instance of the greatly diminished cost of working fire engines as compared with the old hand-worked engines, at the large fire at Beale's Wharf in Tooley Street, which occurred on the 30th October, 1866, eight steam fire engines threw 6,000 tons of water at an expense of £5 5s.; to do the same work in the same time, eighty manuals would be required at an expense of £600.

Prices of Vertical Fire Engines, Fig. 418.

Size number	1	2
Indicated horse-power	27	32
Gallons delivered per minute	300	350
Diameter of jet if only one, in inches	1	1⅛
Height of jet in feet	150	160
Price complete (without hose)	£420	£480
Weight in cwts.	28	31
Measurement in cubic feet	293	348

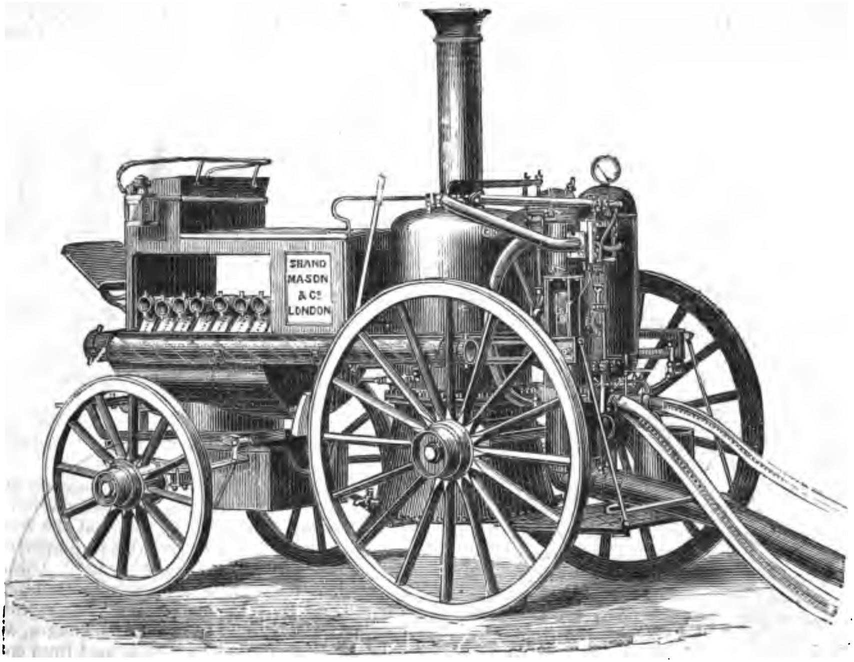


Fig. 418.

THE VERTICAL STEAM FIRE ENGINE, Fig. 419, is fitted with a set of treble pumps worked direct by a corresponding set of treble steam cylinders, whereby perfect uniformity is maintained in the flow of water through the hose and suction pipes, all shocks to the engine or pipes are avoided, and the streams from the jets are as steady as those obtained from pressure due to gravitation. The use of three steam cylinders, besides securing uniformity of flow from the jets, admits of the fly-wheel being dispensed with, the simple valve gear required with the cranks and rotary motion being retained. It also admits of great economy in the use of steam, whereby small boiler space and light consumption of fuel are obtained, and the total weight of the engine is reduced to the minimum. The boiler is of the vertical multitubular type, and steam at a pressure of 100 lbs. per square inch can be raised from cold water within ten minutes from lighting the fire.

The prices above and on the preceding and following pages include steam and water gauges, feed pump, Gifford's injector, set of spare spanners and gauge glasses, suction strainer, set of nut wrenches, hose, suction, branch, and jet pipe wrenches; screw wrench, stoking irons, copper branch pipes, gun-metal jet pipes, a pair of carriage lamps and an engine lamp, tube brushes, oil and tallow cans, two canvas water bags to protect wheels, pole and sway bars for horses, and all necessary fittings excepting hose and suction pipes.

PRICES OF TREBLE VERTICAL FIRE ENGINE, Fig. 419.

Size number	3	4	5
Indicated horse-power	40	60	90
Gallons delivered per minute	450	670	1000
Diameter of jet if only one, in inches	1¼	1½	1⅞
Height of jet in feet	170	185	200
Price of engine	£700	£900	£1100
Extra for packing for shipment	14	15	17
Approximate weight in cwts.	36	42	56
Approximate measurement in cubic feet	382	420	550

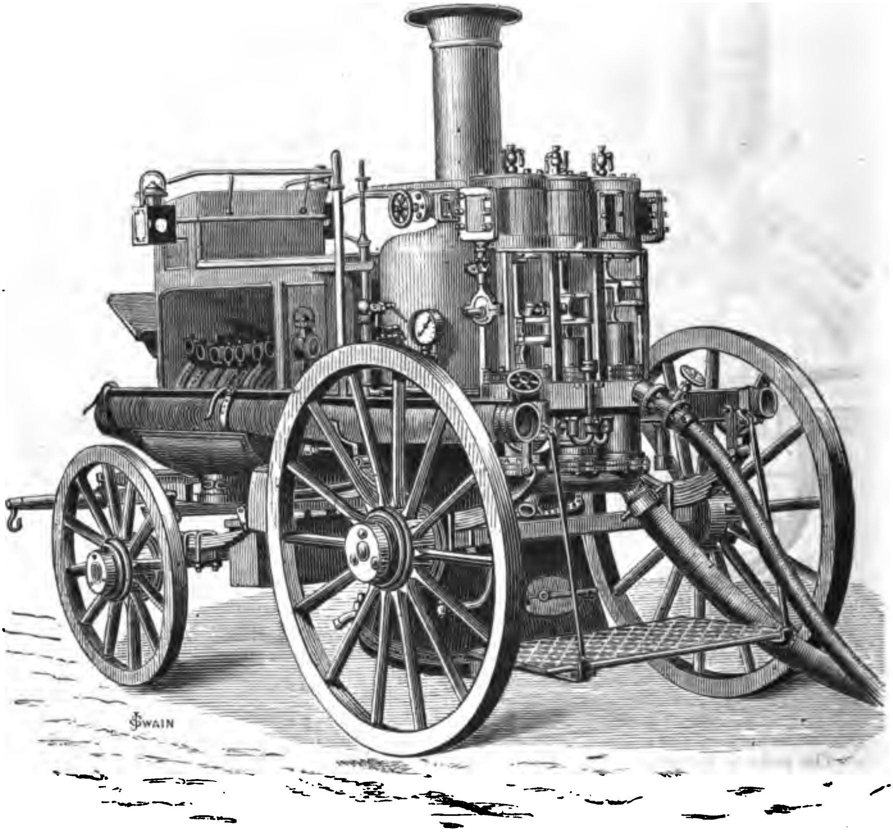


Fig. 419.

THE SINGLE HORIZONTAL STEAM FIRE ENGINE, Fig. 420, delivers 300 gallons of water per minute through a 1-inch jet to a height of 150 feet. It is of simple construction, the pumps and all the working parts being readily accessible. The engraving shows a vertical multitubular boiler with a large fire-box for burning wood; this is only required in places where coal and coke are exceedingly scarce. The engine is so arranged that the pumps can be disconnected and the power taken by a strap from the pulley shown on the crank shaft, when the engine can be applied to any of the purposes for which an ordinary portable engine is employed. The engine and pump are carried on a light wrought-iron frame fixed to the boiler at one end, the other end being carried on the front pair of wheels, these being arranged for shafts and locking gear. The travelling wheels are made entirely of iron, combining strength and durability with lightness; they can, however, be made of wood if preferred, or mounted on steel springs. Wooden-spoked wheels are generally used in climates similar to our own, but in very hot climates iron wheels have many advantages.

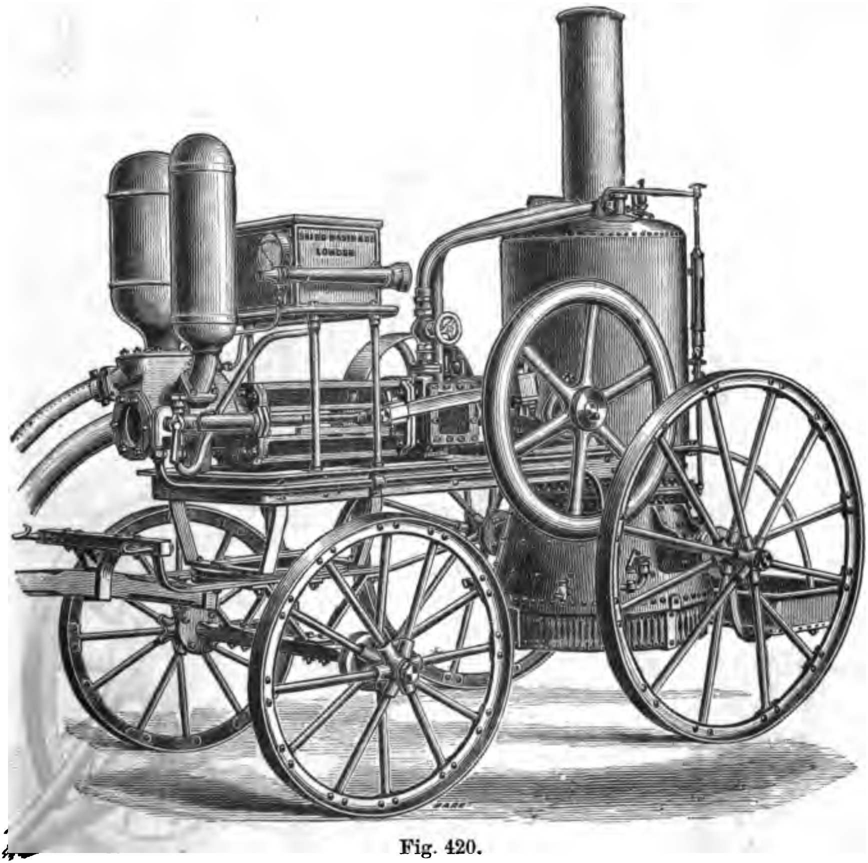


Fig. 420.

The price of the engine, including all necessary boiler fittings and implements, but exclusive of hose and suction pipes, with wood-spoke wheels, furnace constructed for burning coal, but without the motive power arrangement, is £340.

Extra for wrought-iron wheels	£20	0	0
Extra for large fire-box for burning wood	£10	0	0
Extra for arrangement to make engine serve as ordinary portable ..	£20	0	0
Extra for fitting all four wheels with steel bearing springs	£20	0	0
Extra for packing and delivery at dock or railway station in London ..	£12	0	0

THE PORTABLE STEAM FIRE ENGINE, Fig. 421, is not intended to compete with the fire engines required in large towns and cities, but being simple in construction and moderate in cost, it is well adapted for small towns, volunteer fire brigades in country districts, as well as for use about farms, mansions, &c., where property of great value is so often entirely unprotected against fire.

The pump is readily detached from the engine, which is then available for driving chaff-cutters, saw-benches, or other machinery, whilst the pump provides the ordinary water supply for a town, estate, or mansion, and is often of great value in drainage or irrigation operations.

The boiler is vertical, fitted with brass tubes, and has sufficient heating surface to generate steam to a pressure of 100 lbs. per square inch in 20 minutes after lighting the fire. It is tested to a pressure of 200 lbs. per square inch, and is supplied with all the usual furnace and steam fittings, polished brass dome and chimney, copper steam and exhaust connections between the engine and boiler, copper pipe from the feed pump, and all appliances for working with safety and economy.

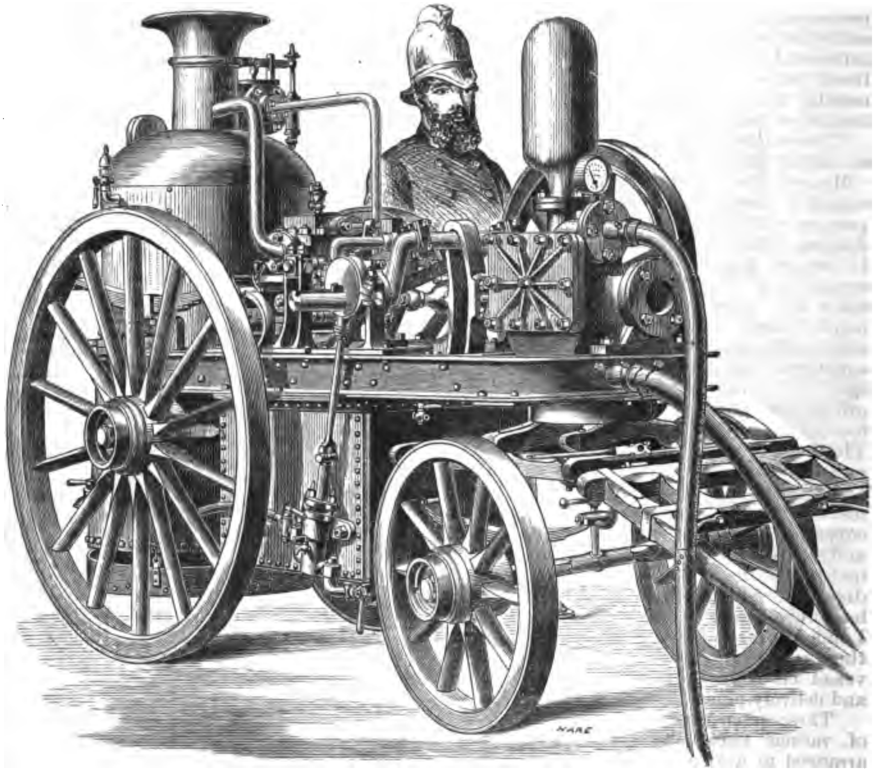


Fig. 421.

The pump is double acting, lined with gun-metal, and fitted with gun metal valves easily accessible, large copper air-vessel, and gun-metal suction and delivery hose connections of the London Fire Brigade pattern.

The whole is mounted on a neat wrought-iron frame, with steel springs, travelling wheels with patent axles, swivelling fore-carriage, shafts or pole.

The total weight is about 35 cwt. and, when working at a moderate speed, the engine delivers 180 gallons of water per minute through a jet ⅞ inches diameter, to a height of 130 feet.

To perform this duty by a manual engine would require thirty-six men at the pumps, or, with relays, not less than sixty men, exclusive of those attending to the hose, &c.

Price of the engine, well fitted and finished throughout, £325.

These engines are built by the Author's firm, and are in use in this country, Russia, &c.

DIRECT-ACTING FIXED STEAM PUMP OR FIRE ENGINE, Fig. 422, is suitable for pumping large quantities of water for factories, railway stations, public works, town supply, &c., as well as for use as fixed or floating steam fire engines; the working parts are principally of steel, and the crank plates are made to balance the piston, cross-head and rods.

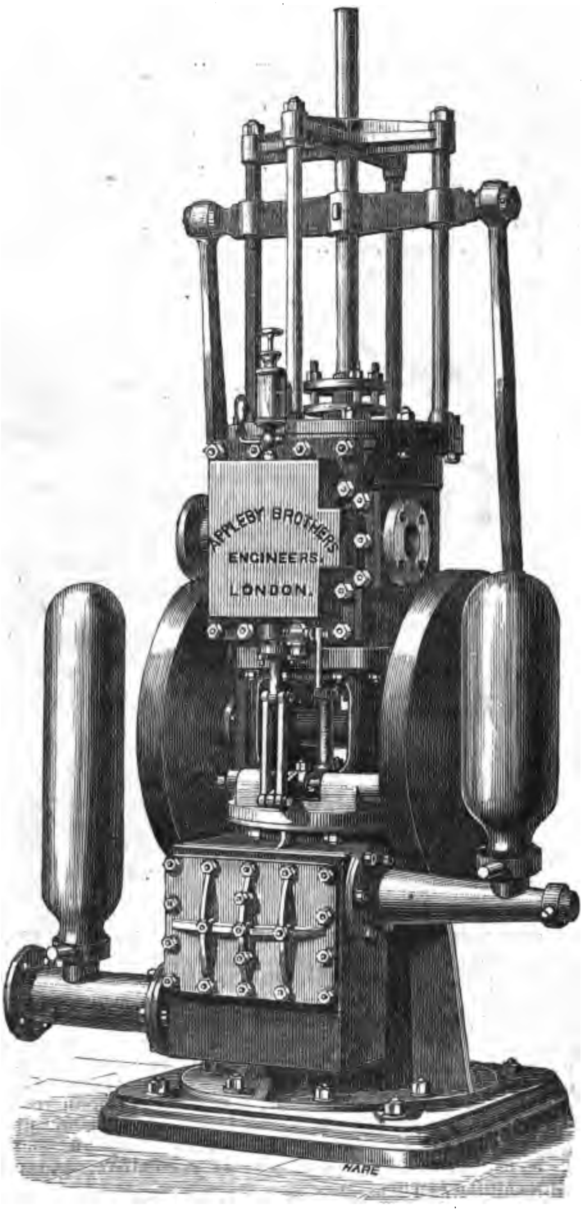


Fig. 422.

The pump is double acting, delivering the full capacity of the barrel at both the up and the down stroke; and when required for use in sea-water the whole of the pump, valve-plates, guards, covers, glands, piston, piston-rod, bolts, and nuts, and all parts coming in contact with salt water, are made of hard gun metal; for pumping fresh water the barrel is usually made of iron, and the valves, &c., of gun metal.

The engraving represents an engine fixed on board the "Mystery," which was designed to answer the double purpose of a steam tug and floating steam fire engine. It occupies a space of 3 feet square by 8 feet high, and takes the steam from the boat's boilers. With a pressure of 25 to 30 lbs. per square inch, the pump throws 500 gallons of water per minute to a height of 150 feet through a 1⅜ inch nozzle. The pump is 8½ inches diameter by 14 inches stroke, and is made entirely of gun metal, the suction pipe is of copper, 5 inches diameter, and the delivery pipe is 5 inches tapering to 2½ inches diameter, and fitted with hose-unions as used by the London Fire Brigade, and there is a large copper air-vessel on both the suction and delivery pipe.

These pumps are made of various sizes, and are arranged to work vertically or horizontally to suit the position in which they can be fixed; in small vessels the deck is cut away to make room for the upper part of the pump.

The price of the engine complete, as shown in Fig. 422, but not including suction, delivery pipes, or any steam, is £300.

The cost of packing and delivery at dock or railway station in London is 5 per cent.

The weight when packed is about 2 tons.

The following list of prices of suction and delivery hoses will be found useful in estimating the probable cost of a steam fire engine complete with the necessary pipes:—

Prices of Suction and Delivery Hose.

Size number of fire engines		1	2	3	4	5	6
No. of gallons per minute		300	350	450	670	1000	1500
Best india-rubber suction in 10 ft. lengths with couplings		£6 6	£7 18	£7 18	£9 18	£12 0	£14 10
Best copper rivetted leather hose in 40 ft. lengths, with couplings, &c.		£8 10	£8 10	£8 10	£8 10	£8 10	£8 10
Best woven canvas hose, prepared to prevent rot, in 100 ft. lengths, with couplings, &c.	No. 1 quality	£8 10	£8 10	£8 10	£8 10	£8 10	£8 10
	No. 2 quality	£7 5	£7 5	£7 5	£7 5	£7 5	£7 5
	No. 3 quality	£6 0	£6 0	£6 0	£6 0	£6 0	£6 0

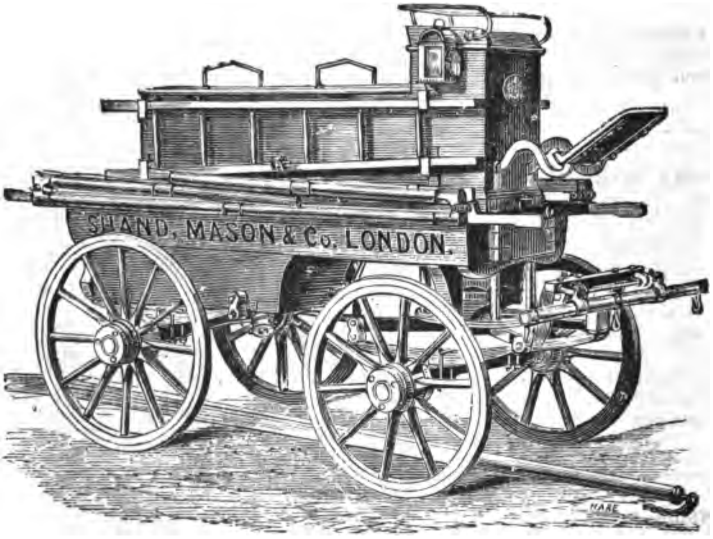

SHAND, MASON & Co. LONDON.

Fig. 423.

THE LONDON BRIGADE MANUAL FIRE ENGINE, Fig. 423, is a very complete hand-worked fire engine, and is especially adapted for municipal, country, volunteer, and private fire brigades; it is light, yet strongly built. The works are of the best description, being fitted with metallic valves, two gun-metal cylinders and pistons, copper suction and delivery air-vessels, and are fixed in a strong well-seasoned oak cistern, with side pockets to carry suction and branch pipes, and a box placed over the cistern to carry hose and implements, with driving-seat and footboard, wrought-iron forelocking carriage and drag handle, with pole and sway bar for a pair of horses, springs and high wood-spoke wheels for rapid travelling, draws water either through suction-pipe from pond, rivers, &c., or from cistern of the engine, &c., and delivers on either or both sides. Each engine is provided with a copper branch pipe, having gun-metal screw to attach to hose, and boss to take jet pipe, two jet pipes, a copper strainer with gun-metal screw to fix on end of suction-pipe, a wrench for suction air-vessels, two hose wrenches, and a screw driver with shifting handle.

These engines are adopted by the Metropolitan Board of Works, the Volunteer Brigades in the neighbourhood of London, and almost all the large towns and districts in England, the various Insurance Offices, Her Majesty's War Department, Admiralty, Council of India, the Colonies, and in many foreign countries.

Prices of Brigade Manual Engines, Fig. 423.

Gallons delivered per minute	80	100	115	134	174	218
Height of jet in feet	110	120	125	130	140	150
Maximum number of men to work pumps	16	22	26	30	36	46
Price	£120	£135	£145	£155	£165	£180

COUNTRY BRIGADE MANUAL FIRE ENGINE suitable for small towns and thinly inhabited rural districts, and may be drawn by one horse at considerable speed. This engine has been designed for use in localities where the purchase of a London Brigade engine is too heavy a tax on the inhabitants. The Country Brigade Engine is as powerful when worked by the same number of men as the London Brigade Engine, but the exterior arrangements are less expensive. The works are similar to the London Brigade Engine, and it is fitted with locking carriage springs, wrought-iron axles, shafts for one horse, four wood-spoke wheels, and driving seat and footboard; will carry men, and travel at considerable speed.

Prices of Country Brigade Engines.

Gallons delivered per minute	80	100	115
Height of jet in feet	110	120	125
Maximum number of men to work pumps	16	22	26
Price	£98	£112	£124

FACTORY MANUAL FIRE ENGINE. This engine is designed for use in railway stations and works, ship-building and timber yards, factories, docks, &c., and is not required to be drawn by horses. It is adopted by the Admiralty, the London, Brighton, and South Coast, the South-Eastern, and other railway works. These are powerful engines, and are similar to the London Brigade engines, but without springs, gear for horses, driving seat and footboard, and are arranged for being drawn by a drag handle.

Prices of Factory Fire Engines.

Gallons delivered per hour	80	100	115	134	174	218
Height of jet in feet	110	120	125	130	140	150
Maximum number of men to work pumps	16	22	26	30	36	46
Price	£108	£122	£131	£140	£149	£162

MANSION MANUAL FIRE ENGINES for the protection of private mansions, small villages, railway stations and works, manufacturing and other premises, to be taken to short distances only, being made very light for that purpose. The pumps are as powerful as those of any other classes of engine worked by the same number of men. It is similar to the Country Brigade Engine, but without springs, shafts, driving seat, and footboard, and is much used for the above-mentioned purposes in all parts of England, and in many foreign countries.

Prices of Mansion Fire Engines.

Gallons delivered per minute	44	55	70	80	100	115
Height of jet in feet	80	90	100	110	120	125
Maximum number of men to work pumps ..	6	8	12	16	22	26
Price	£50	£60	£76	£86	£96	£105

METALLIC MANUAL FIRE ENGINES are modifications of the factory and mansion fire engines, rendering them more suitable for use in tropical climates, by the substitution of copper instead of wood in the construction in the cistern in which the working parts are fixed, with a view of resisting the attacks of insects and the effects of climate. Five sizes of these engines are manufactured. Nos. 1 and 2 are suitable for brigade purposes; No. 3 is much used for mansions and extensive premises, and frequently as a garden engine in grounds of great extent it is readily worked by two or four men, six men being the full number. Nos. 4 and 5 are suitable for use in manufacturing and other premises where they will not have to run out to fires at a distance.

Prices of Metallic Fire Engines.

Gallons delivered per minute	218	174	134	115	100	80	70	55	44	35
Height of jet in feet	150	140	130	125	120	110	100	90	80	75
Maximum number of men to work pumps	46	36	30	26	22	16	12	8	6	4
Price of engine, No. 1	£160	£150	£140	£132	£126	£113	..	..	..	..
Price of engine, No. 2	..	..	..	..	£108	£94	£78	£62	..	..
Price of engine, No. 3	..	..	..	..	..	..	..	..	..	£25
Price of engine, No. 4	..	..	£84	£73	..	£63	..	..	..	..
Price of engine, No. 5	..	..	..	..	..	..	..	£48	£36	..

THE CURRICLE MANUAL FIRE ENGINE is extensively used by the London Fire Brigade, the Council of India, and country fire brigades, and is made both for hand and horse draught. It is extremely light, and being mounted on springs and high wheels, is easily drawn. It carries all appliances for extinguishing fires, and is a complete fire engine at a very small cost.

Prices of Curricle Fire Engines.

Gallons pumped per minute	55	68	100
Height of jet in feet..	90	100	120
Maximum number of men to work pumps	10	16	22
Price for horse draught	£54	£66	£78
„ hand draught	£42	£53	£66

Thirty-one hand curricle engines are now employed by the London Fire Brigade alone.

Prices of Hose for use with Manual Engines.

Max. number of men to work pumps	6	8	12	16	22	26	30	36	46
Copper rivetted leather hose per 40 ft. length with couplings, loops, &c.	100/-	108/-	120/-	135/-	150/-	158/-	170/-	170/-	170/-
Patent woven canvas hose per ft. No. 1	7*d.*	8*d.*	8½*d.*	9*d.*	10*d.*	10½*d.*	11*d.*	11*d.*	11*d.*
„ „ No. 2	9*d.*	10*d.*	10½*d.*	11*d.*	12*d.*	13*d.*	14*d.*	14*d.*	14*d.*
„ „ No. 3	11*d.*	12*d.*	13*d.*	14½*d.*	15*d.*	16*d.*	17*d.*	17*d.*	17*d.*
Gun-metal couplings for do. (fixed), each pair	10/	11/4	13/4	14/6	16/8	18/-	20/-	20/-	20/-
Leather or india-rubber suction hose per ft.	4/6	5/1	5/8	6/8	7/4	7/10	8/6	10/-	12/-
Gun-metal couplings for do. (fixed), each pair	13/-	14/-	16/-	18/-	20/-	22/-	24/-	26/-	30/-

Leather hose is usually made in 40-ft. lengths, a coil of that length being as much as one man can handle. Woven canvas can be had in any length up to 600 feet, and is about 1-5th the weight and bulk of leather; it can be prepared to prevent rot at an extra expense of 1*d.* per foot, and will then last for many years, although it is not so durable as leather which, if properly looked after and occasionally oiled, ought to last forty years.

RESPIRATORS AND EYE PROTECTORS to enable men to enter and remain in a room full of smoke or noxious vapours, are important additions to the outfits of fire brigades. These appliances, with from 30 to 50 feet of tubing, are usually kept in readiness with every fire escape. It sometimes happens that a fireman, on entering a burning house to rescue the inmates, is obliged to retire in consequence of the suffocating smoke, and in fact on one occasion a fireman so engaged was with difficulty saved from suffocation. A very simple apparatus for this purpose has been exclusively used in the London fire brigades for some time past. The price of the respirator complete, with 30 feet of tubing, is £5 10*s.*, or with 50 feet of tubing, £7 10*s.* The price of a pair of patent eye protectors to be used in conjunctien with the respirators is £1 5*s.* Every ship should carry at least one set of this apparatus.

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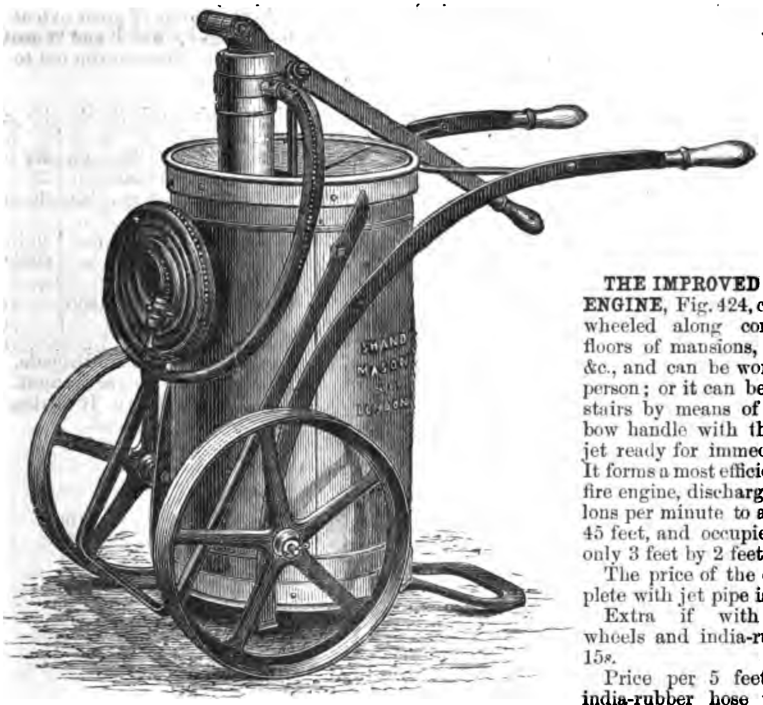

Fig. 424.

THE IMPROVED CORRIDOR ENGINE, Fig. 424, can be easily wheeled along corridors and floors of mansions, warehouses, &c., and can be worked by one person; or it can be carried upstairs by means of the hinged bow handle with the hose and jet ready for immediate action. It forms a most efficient portable fire engine, discharging ten gallons per minute to a distance of 45 feet, and occupies a space of only 3 feet by 2 feet.

The price of the engine complete with jet pipe is £6 10*s.*

Extra if with mahogany wheels and india-rubber tyres, 15*s.*

Price per 5 feet length of india-rubber hose with swivel screws bound on with copper wire, 8*s.*

Price of copper-rivetted leather or india-rubber hose in 10 ft. lengths with swivel screws fixed with copper wire, 15*s.*

The cistern is made of strong galvanized iron, and is of sufficient capacity to contain twelve gallons; and although mounted on high wheels it is kept sufficiently near the ground to ensure stability when at work.

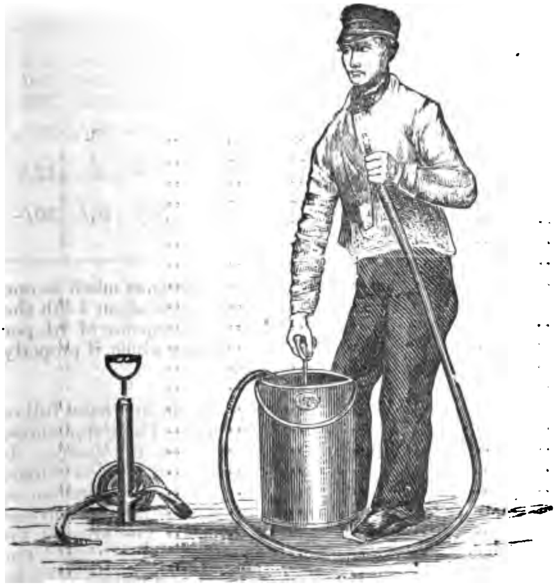

Fig. 425.

PORTABLE HAND FIRE PUMP, Fig. 425, was introduced by the London Fire Engine Establishment a few years ago, since which time it has been constantly in use, and found of great service, many fires being extinguished through its instrumentality.

The air vessel, barrel, and valves are entirely of brass, not liable to get out of order, and the whole can be kept in any convenient situation, ready for immediate use.

This pump will force six gallons per minute to a height of 30 feet.

Price with 10 feet rivetted leather hose, swivel screws and jet pipe, 50*s*.

Galvanized iron pail, with internal socket for reception of the pump, by which one person can work and direct the jet, 12*s*. 6*d*.

Extra for metallic cover to enclose pump and hose, 5*s*.

THE IMPROVED HOSE REEL, Fig. 426, consists of a pair of high wood wheels with a wrought-iron axle; a reel to hold the hose revolving on the handle, but independent of it. A wrought-iron frame fixed to the axle carries the box and forms a drag handle. The box at the top is arranged to contain a stand pipe, branch pipe, and other necessary implements.

These hose reels are frequently mounted on springs for being drawn at high speeds and are generally employed by London, provincial, and volunteer brigades.

When kept ready for use the whole of the hose is connected by the couplings into one length and coiled on the reel, a ferrule screw being left outside, and all the implements are in their places in the box. On an alarm of fire the hose reel is run by one or two men to the fire plug nearest to the premises on fire, the hose is connected to the plug or stand pipe and the machine is moved as near the fire as possible, the hose being uncoiled and laid on the ground by the reel in its progress; the hose is then disconnected at the nearest coupling, a branch pipe screwed on, and the whole is ready for the water to be turned on.

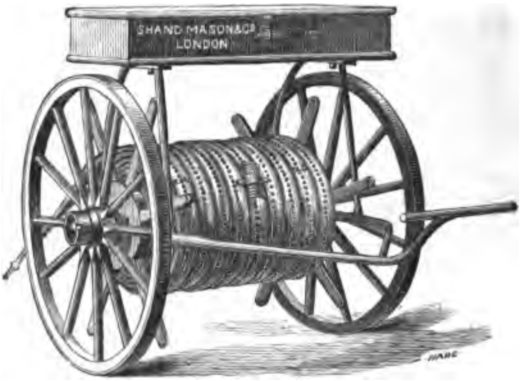

Fig. 426.

PRICES OF HOSE REELS, Fig. 426.

Reel for 400 ft. of leather, or 1500 ft. of canvas hose		£13	10	0
Extra for ditto if mounted on springs		4	10	0
Reel for 600 feet of leather hose mounted on springs		28	0	0
Reel for 1000 ft. of leather hose mounted on springs		38	0	0
Copper branch pipes	from 17/- to	1	10	0
Felling axe		0	11	0
Light fire axe		0	8	6
Hand axe		0	6	0
Hand axe with belt and case		0	14	0
Pickaxe		0	5	6
Spade		0	5	0
Crowbar		0	6	6
Fire hooks		0	13	6
Hand lamp		0	15	0
Hand saw in leather case		0	16	6
Scaling ladders per pair		2	10	0
Bright hose wrench		0	3	6
Black hose wrenches		0	2	0
Grappling-iron and 36 feet of chain		1	0	0
Canvas pails per doz.		2	10	0
Copper-rivetted leather pails per doz.	140/- and	8	0	0
Folding canvas cisterns, according to size	50/-, 150/- and	8	10	0
Helmets	from 15/- to	1	5	0

HYDRAULIC RAMS of the kind illustrated by Fig. 427 are used for such purposes as irrigating lands, supplying farm buildings, factories, railway stations, &c. The hydraulic ram was invented by Montgolfier, but since his time has been much improved in detail and construction, and as now made it may fairly claim to be a most efficient and reliable means of supplying water from a running stream to a considerable elevation. It is applicable where no more than 18 inches fall can be obtained, but the greater the fall available the more powerful the action of the machine and the greater the elevation to which the water may be forced. If at all possible a fall of 8 or 10 feet should be obtained. The proportion between the water raised and that running to waste depends mainly on the height of the spring or source of supply above the ram relatively with the height to which the water is delivered. The quantity raised varies in proportion to the height to which it is conveyed with a given fall and the length of the pipe through which the water is forced; the longer the pipe the greater is the friction to be overcome. It is, however, not unusual to apply a ram for forcing water to a distance of 1,000 yards or more. Ten feet fall is sufficient for forcing water to any elevation not exceeding 150 feet above the point where the ram is fixed, and if only a small quantity of water is required and a large quantity is available in the brook or other source of supply, the water may be raised to a much greater height than 150 feet. It is not advisable to use a greater fall than is absolutely necessary to raise the required quantity of water to the desired height, as the ram is then subjected to an unnecessary amount of work, the wear and tear of all the parts is increased, and the durability of the whole is proportionately decreased. If the ram is fixed at a reasonable distance from the point where the water is to be delivered the fall necessary to deliver a given quantity is approximately as follows. About one-seventh part of the water will be raised to five times the height of the fall which is applied to the ram, or about one-fourteenth part will be raised to ten times the height of the fall, and so on in the same proportion. Thus, if the ram be placed under a head or fall of 10 feet, and the stream delivers 50 gallons per minute, about 7 gallons per minute can be raised to a height of 50 feet, or 3½ gallons to a height of 100 feet; or, in other words, an efficiency of 70 per cent. is obtained. This compares favourably with other forms of pumping machinery, and the rams possess this great advantage, that they can be allowed to work continuously and will require no attention whatever, and beside being very cheap in first cost, they are inexpensive in maintenance. The ram should be fixed in a pit 2 or 3 feet deep, sufficient to protect it from frost, and a race should be cut to convey the waste water away. The pipes should also be laid at such a depth in the ground that they are out of the reach of the severest frost. The prices below do not include any piping.

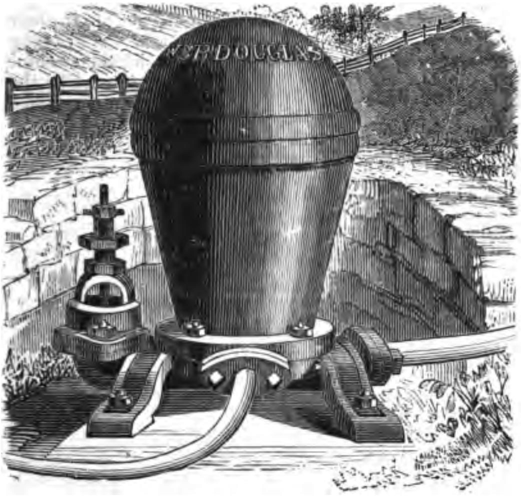

Fig. 427.

PRICES OF HYDRAULIC RAMS, Fig. 427.

Size number	2	3	4	5	6	7	10
Max. gallons in stream per minute	2	4	7	14	25	40	75
Diameter of supply pipe in inches	¾	1	1¼	2	2½	2½	4
Diam. of discharge pipe in inches	⅜	½	½	¾	1	1¼	2
Price	£2 0	£2 6	£3 0	£4 15	£8 10	£12 10	£33 0

Packing and delivery about 5 per cent.

THE PULSOMETER, Fig. 428, is a simple and cheap appliance whereby water and most other liquids whether clear or turbid may be raised by the force of steam, and delivered in a constant stream to a height of from fifty to eighty feet, without the intervention of a pumping engine, and it is specially adapted for sinking wells, making foundations, &c. It will be found useful to manufacturers and mine owners whenever a pump is required that needs a minimum of attention, or on ships, as it can be applied to a variety of purposes, such as for working ballast tanks, for bilge purposes, for washing decks, or as a fire engine. The simplicity of the pulsometer will be understood from an enumeration of its parts, which are an outer casing divided into two chambers, one ball valve controlling the admission of steam at each pulsation, and the usual suction and delivery valves common to all reciprocating pumps.

The action will be understood by reference to the section engraving (Fig. 429) on the next page. The two chambers A A are contained in one casting and are gradually tapered upwards till they unite in a neck J; this neck contains the steam ball valve, which by its oscillation admits steam alternately to each chamber. The chambers A A are connected at the bottom by a breeches piece, which leads to the suction pipe L and carries the two suction valves CC. On the side of the chamber D is attached a discharge box containing the delivery valves and leading to the discharge pipe. Doors are provided for easy access to all the valves. The pumps being filled with water, steam admitted through the pipe N passes down whichever side of the steam neck is left open by the position of the steam ball, and presses on the small surface of water exposed to it, depressing it without any agitation, and consequently with very slight condensation, and thus driving it through the delivery valves into the rising main. The moment that the level of the water is as low as the horizontal orifice leading to the discharge chamber, the steam blows through with a certain amount of violence, the surface of the water becomes agitated, an instantaneous condensation takes place, a vacuum is formed in the chamber, and the steam ball is pulled over into the seat opposite to that which it had occupied during the operation just described. The same action then takes place in the second chamber, and by this means a continuous stream is discharged. As the valves are the only moving parts, they and their seats are the only portions ever requiring to be renewed; these renewals are only necessary at very long intervals, and can be effected in a very short space of time and at a comparatively insignificant cost. The pulsometer is capable of pumping water or other liquids containing from 15 to 50 per cent. of muddy, pulpy, or gritty substances, and can be employed for raising a variety of chemicals, ammoniacal, or tan liquors, or even tar.

The illustration, Fig. 428, shows a pulsometer engaged in sinking work. It will be observed that it is merely suspended in chains, no further fixing being required; and as steam is supplied through a flexible tube, the pump can easily be lowered as the operation of sinking advances. These pumps are suited for this class of work, for draining quarries or mines, as they occupy a small space and require little attention. Messrs. Pope and Pearson, of the West Riding and Silkstone Collieries, near Leeds, state that one employed by them "continued working uninterruptedly for a fortnight without any one going near it." When the water is to be raised to a considerable height it is desirable to insert a retaining valve in the lower part of the rising main, and in all cases a foot valve must be placed at the bottom of the suction pipe.

Prices of valves suitable for these will be found in the annexed list.

The number of gallons delivered in the table is with a discharge of 15 feet, and an allowance must be made if the height is materially increased.

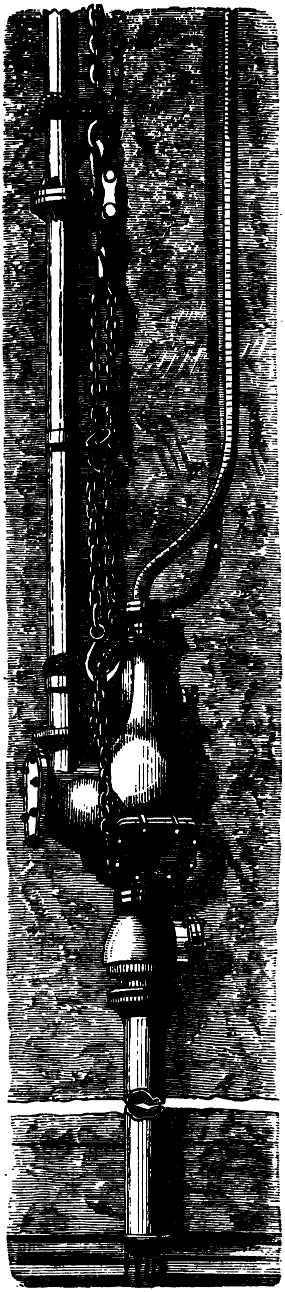

Fig. 428.

PRICES OF PULSOMETERS, Fig. 428.

Size number	1	2	3	4	5	6	7	8	9
Diam. of steam pipe ..	¼	¼	½	½	¾	1	1	1¼	1½
" suction ..	1½	2	3	4	4½	5	6	7	8
" discharge ..	1	1½	2	2½	3	3½	4	5	6
Gallons raised per hour	500	1450	3000	5000	9000	13,200	17.000	26,000	30,000
Price	£13	£20	£26	£35	£45	£55	£70	£100	£120
Price of foot valve ..	£1 5	£1 15	£2 15	£3 10	£4 0	£4 15	£5 5	£6 0	£7 10
Price of retaining valve	£1 5	£1 15	£2 10	£2 18	£3 5	£4 0	£4 15	£5 5	£6 0

Packing for delivery costs about 5 per cent.

THE HYDROTROPHE, Fig. 429, is a form of pulsometer specially adapted to feeding boilers, and like it is so simple in construction and action as to require little or no attention, is not subjected to great wear or tear, and the parts which may in course of time become worn out are easily, quickly, and cheaply replaced without the employment of skilled labour. The valves and seats are, however, made of the hardest description of phosphor bronze, and will probably last for many years; the body of the hydrotrophe cannot possibly wear out, so that the expense of a new set of valves and seats renders the whole as valuable as when first purchased. The pump may be fixed in any convenient position relatively with the boiler, either upon it or at some distance from it; the only essential condition being that the discharge flange should be at least 18 inches above the normal level of the water in the boiler. Steam should be supplied through a wheel valve screwed into the opening N by means of a pipe taken from a point in the boiler above the water line, and the discharge pipe should be led into the boiler below the water level. The suction pipe may be taken to a tank eight or nine feet below, or any height above, the apparatus, and a fine strainer should be provided on this pipe. The quantity of water delivered can be regulated at pleasure, and no overflow pipe is required as in injectors.

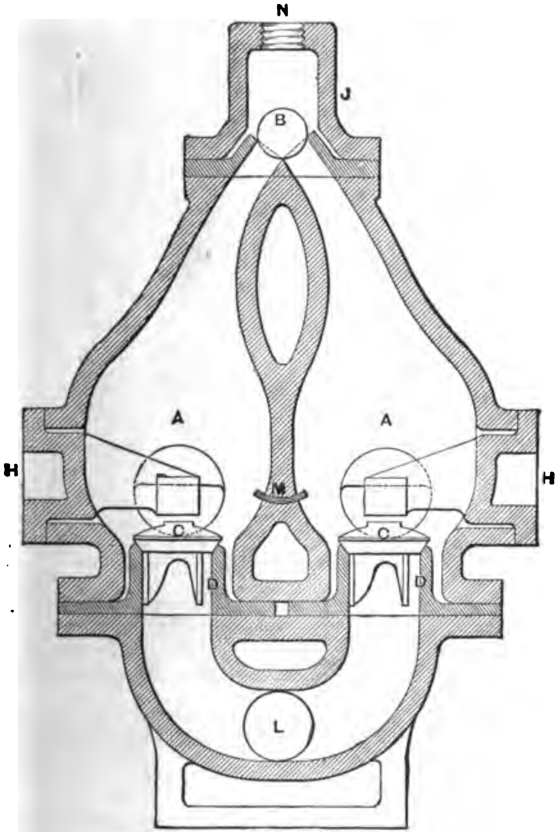

Fig. 429.

PRICES OF THE HYDROTROPHE, Fig. 429.

Size number	1	2	3
Horse power of boiler to be fed	10 to 15	35 to 40	70 to 80
Price with foot valve complete	£13	£16	£23

Packing for shipment costs about 5 per cent.

HYDRAULIC FORCE PUMPS, Fig. 430. These are applicable to a great variety of purposes, such as for working hydraulic presses, hoisting machinery or machine tools. Amongst hoisting machinery alone might be enumerated many varieties, such as cranes, travellers, lifts, and jacks; whilst amongst machine tools may be mentioned punching machines, shearing machines, rivetting machines, &c. These pumps are neatly designed, and are specially adapted for constant work under any pressure up to 1,500 lbs. per square inch; at this pressure they may be driven at 80 strokes per minute. To adapt them for working at these high pressures and speeds very large bearing surfaces are provided throughout, and only the hardest description of gun metal is employed for valves, barrels, and bearings. The crank shaft is entirely of steel and runs in long gun-metal adjustable bearings.

Especial attention is directed to the fact that the thrust of the pumps is taken by the solid metal, and not, as is usually the case, by a bearing cap and bolts. This is a feature belonging especially to these pumps and insures great durability and efficiency.

The pumps are mounted on a strong base-plate which forms a tank. The connecting-rods are of forged scrap iron, the lower end is forked to span the guide blocks and the upper end is fitted with adjustable gun-metal bearings of the marine pattern; the connecting-rods are made very long in proportion to the stroke of the pumps, thus avoiding any excessive side pressure on the bearings and guides. The pumps are arranged to be driven by a strap, a fast and loose pulley being provided on the crank shaft between its bearings; the loose pulley is bushed with gun metal and the fast pulley is made sufficiently heavy to act as a fly-wheel. The workmanship and materials throughout are of the highest quality, and the pumps are strongly recommended for employment wherever hydraulic pressure is extensively used.

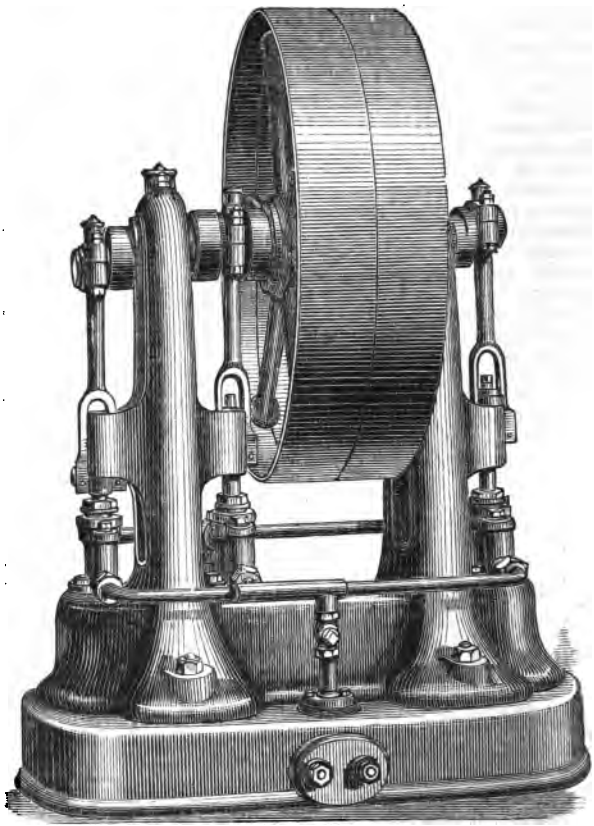
Fig. 430.

The pumps are made in sets of two and three, the latter being preferable on account of the more regular delivery of water. Prices of both are given below.

PRICES OF HYDRAULIC FORCE PUMPS, Fig. 430.

Number of rams	2	3	2	3	2	3	2	3
Diameter of rams in inches	1¼	1¼	1½	1½	1¾	1¾	2	2
Stroke of rams in inches	4	4	4	4	4	4	4	4
Revolutions per minute	80	80	80	80	80	80	80	80
Approximate weight in cwts.	16	20	26	28	28	30	32	34
„ measurement in cubic feet ..	71	85	71	100	100	100	100	100
Price	£100	£115	£115	£145	£145	£160	£160	£180

Packing for delivery about 5 per cent.

HAND-POWER HYDRAULIC PUMP, Fig. 431, is an exceedingly neat pump, fitted with single plunger, and is available for a variety of purposes, such as attaching to any form of hydraulic press of small size, for lifts, testing boilers, pipes, or cylinders, or for use in connection with machines for testing girders, iron, &c.

The base forming the cistern is of cast iron, circular in shape, and with lugs for bolting to the foundations when required; the standard is attached to the tank by a stretcher across the top of the tank, and carries the pump in the centre, the lower part of the pump reaching close to the bottom of the tank; the top of the standard is bushed with gun metal, and forms a vertical guide to the plunger. The hand lever is hung on one side of the standard, and is fitted with moveable adjustable fulcrum pin; the opposite side is slotted to guide the lever; this lever is made with a socket joint about midway of its length, so that it can be used to give a quick stroke for filling boilers, &c. The pump plunger and valves are all of hard gun metal, and the pump is fitted with safety valve and pressure gauge to indicate any pressure up to 2 tons per square inch. Price of the pump, £20; pressure gauge, £2 to £4, according to pressure. The plunger of the pump is 1¼ inches diameter.

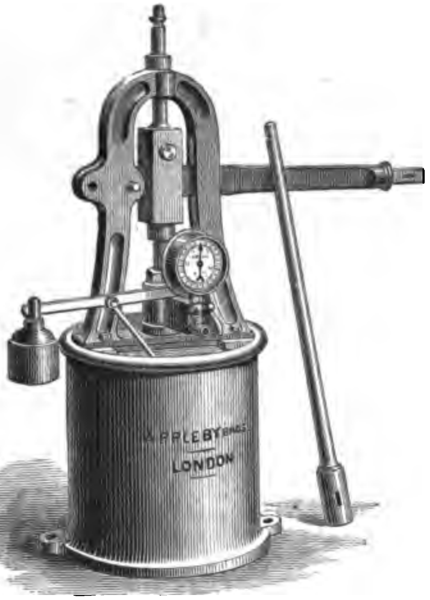

Fig. 431.

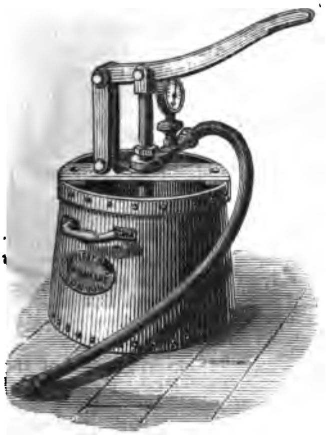

Fig. 432.

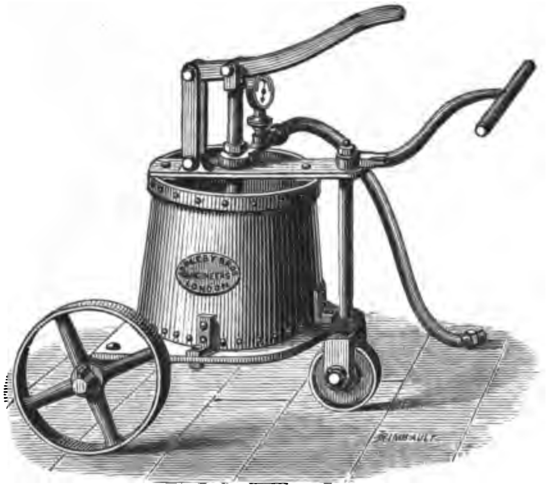

Fig. 433.

PORTABLE TEST PUMPS, Figs. 432 and 433. These are handy forms of portable hydraulic test or proving pumps for use under many conditions where the pressure required does not exceed above 300 lbs. The pump, Fig. 432, can be carried by one man, or it can be fitted with three wheels to be wheeled where required, as shown in Fig. 433, the front wheel being made to swivel. Price of pump, Fig. 432, £7; if with wheels, as Fig. 433, £10 10s.; pressure gauge, £1 1s. extra for either pump.

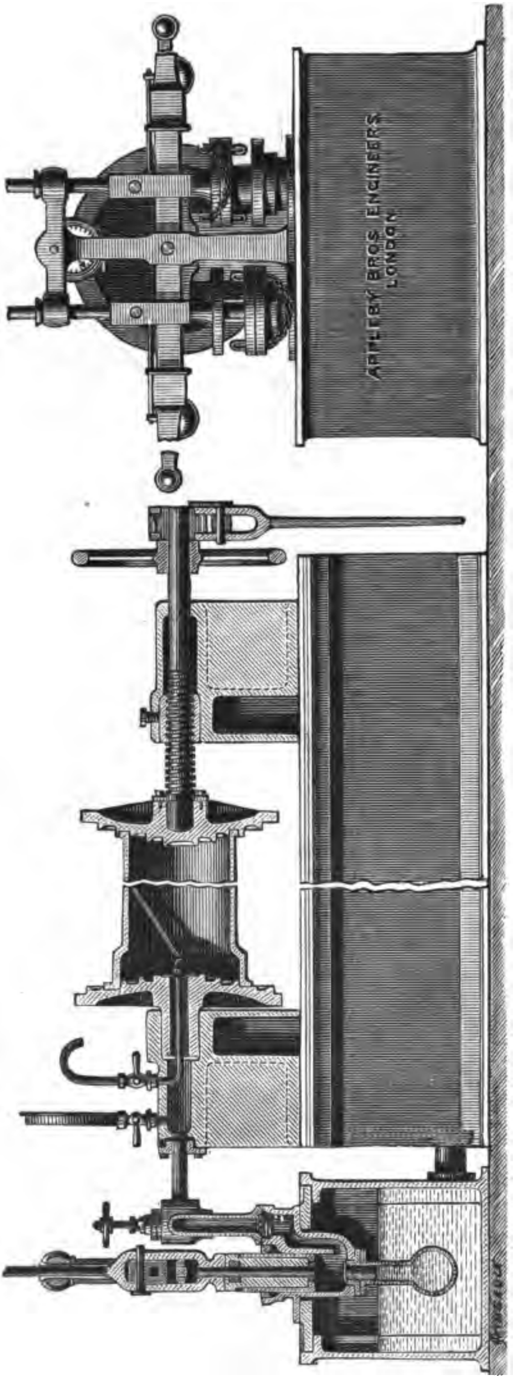

Fig. 433*.

HYDRAULIC PIPE PROVER, Fig. 433*. This machine will be found useful and almost necessary in large water or gas works, as well as to pipe founders. It is constructed to prove pipes of any length up to 9 feet, and of any diameter from 3 inches to 24 inches; for this purpose five pairs of loose discs are provided with the proper diameter of grooves, the discs being readily fitted to the machine and easily changed. A trough is provided of sufficient capacity to charge the largest size pipe, so that the machine can be used in any place where the supply of water is only sufficient to charge the trough; but where water can be obtained from a service pipe or tank, time and labour is saved by charging the pipes from such source of supply.

The pumps are worked by hand power, and consist of a pair of differential plungers; the outer plungers are 5 in. diameter, and within these are plungers 1½ inch diameter, which can be readily fixed to the large hollow plunger, or the hollow plungers to the cistern; the two plungers work together whilst the pipes are being filled, and when the pressure is brought on to the pipe the smaller plunger only is used. Pipes can be tested up to 300 lbs. per square inch.

Each size of groove in the headstocks is fitted with an india-rubber ring, which makes the joint between each end of the pipe and the corresponding headstock, and a screw and ratchet lever is fitted to the moveable head. The water is conveyed into the pipes through the centre of the fixed headstock, which is also provided with a suitable arrangement to get rid of the air, and a pressure gauge indexed to 300 lbs. per square inch. The price of the machine of the size described is £150, and the weight 45 cwt. Other sizes, either smaller or larger, are constructed, and, if desired, the pumps can be driven by hand or power.

If with apparatus to test bends and irregular pipes, £32 extra.

The cost of the pumps only, mounted on tank as shown in Fig. 433*, is £75. Packing and delivery 5 per cent.

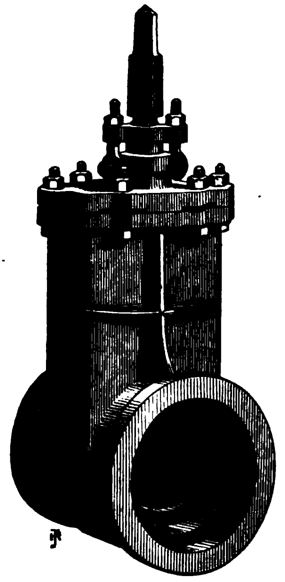
Fig.434.

SLUICE VALVES, Fig, 434. These valves are suitable for steam, water, gas, air, sewage, &c., and are constructed of the best materials. The valve cases are made in cast iron in one piece, and fitted, as may be required, with single or double gun-metal faces to the valves, and seats and gun-metal screws and nuts for steam and water; double cast-iron faces and wrought-iron screws and nuts are generally used for gas and sewage. The outlets can be made with both ends flanged, or with flange and spigot or socket ends, or with spigot and socket or double socket ends, as may be required. The steam and water valves are tested to a pressure of 200 lbs. per square inch, and the gas and air valves with double iron faces are tested to 30 lbs. per square inch before leaving the works. All valves are supplied with cast-iron sockets upon the spindle ends, and if desired may be fitted with hand wheels, the additional cost of which will be found in the subjoined table. If the valves are required with faced flanges the extra cost is given. In the smaller sizes the flanges are faced all over, but in the larger sizes they are only faced from the bore to the inner edge of the bolt holes. Bolt holes may be cast in the flanges or drilled to templates. In cases where the valves are intended to be used with existing pipes, it is always advisable to send a template of the flanges showing the number and diameter of bolt holes, there being no regular standard amongst engineers for the proportion of flanges. These valves are sometimes made with the faces parallel and with plain spindles and handles for blast furnace work.

Nearly all sizes are kept in stock. The cost of packing for shipment and delivery to any of the London Docks will average about 5 per cent.

PRICES OF SLUICE VALVES.

Bore of valve in inches	2	2½	3	4	5
Diameter of flanges	6½	7	7½	9	11
Length over flanges	7	8¼	8½	8¾	10
Centres of bolt holes	5	5½	6	7¼	9
Number of bolts	4	4	4	4	6
Diameter of bolts	½	½	⅝	⅝	⅝
Price with four gun-metal faces, screws and nuts	£1 11 0	£1 19 0	£2 6 6	£3 3 0	£3 18 0
Price with two ditto ditto ..	1 9 6	1 14 0	2 0 0	2 17 0	3 12 0
Price with wrought-iron screws and nuts and cast-iron faces ..	1 5 0	1 10 0	1 15 0	2 5 0	3 0 0
Price extra with spigot and socket ends fitted to valves	0 5 0	0 6 0	0 7 0	0 9 0	0 11 6
Price extra fitted with hand wheels on top of spindles ..	0 2 0	0 2 0	0 2 0	0 2 0	0 2 7
Price extra with faced flanges..	0 1 2	0 1 4	0 1 9	0 2 0	0 2 3

Bore of valve in inches	6	7	8	9	10
Diameter of flanges	12	13½	14½	15½	17
Length over flanges	11¼	12½	13	13¾	15
Centres of bolt holes	10	11¼	12¼	13¼	14½
Number of bolts	6	6	6	6	8
Diameter of bolts	⅝	¾	¾	¾	¾
Price with four gun-metal faces, screws and nuts	£4 15 0	£5 13 0	£6 18 0	£8 0 0	£9 5 6
Price with two ditto ditto ..	4 6 0	5 3 0	6 6 0	7 7 0	8 3 0
Price with wrought-iron screws and nuts and cast-iron faces ..	3 10 0	4 5 0	5 5 0	5 15 0	6 10 0
Price extra with spigot and socket ends fitted to valves	0 15 0	0 19 0	1 4 0	1 8 6	1 12 6
Price extra fitted with hand wheels on top of spindles ..	0 2 7	0 2 7	0 2 7	0 4 6	0 4 6
Price extra with faced flanges ..	0 2 7	0 2 10	0 3 2	0 3 6	0 4 0

Prices of Sluice Valves—*continued.*

Bore of valve in inches	11	12	14	15	16
Diameter of flanges	18	19	21½	22½	23½
Length over flanges	16	17	17¾	18	18
Centres of bolt holes	15½	16½	18¾	20	21
Number of bolts	8	8	8	10	10
Diameter of bolts	¾	¾	⅞	⅞	⅞
Price with four gun-metal faces, screws and nuts	£10 10 0	£11 15 0	£16 10 0	£18 10 0	£20 10 0
Price with two ditto ditto ..	9 9 0	10 12 0	14 10 0	16 10 0	18 12 0
Price with wrought-iron screws and nuts and cast-iron faces ..	7 10 0	8 0 0	12 0 0	13 5 0	15 0 0
Price extra with spigot and socket ends fitted to valves	1 17 0	2 4 0	3 6 0	4 2 0	5 4 6
Price extra fitted with hand wheels on top of spindles ..	0 4 6	0 4 6	0 6 0	0 6 0	0 6 0
Price extra with faced flanges ..	0 4 3	0 5 3	0 6 3	0 6 9	0 8 0

Bore of valve in inches	18	20	24	30	36
Diameter of flanges	25½	28	32½	39	45½
Length over flanges	19	20	21½	24	27
Centres of bolt holes	23	25½	29½	36	42
Number of bolts	12	12	12	16	20
Diameter of bolts .. - ..	⅞	1	1	1¼	1¼
Price with four gun-metal faces, screws and nuts	£24 0 0	£27 10 0	£36 0 0	£50 0 0	£78 10 0
Price with two ditto ditto ..	21 16 0	24 2 0	31 10 0	41 10 0	65 11 0
Price with wrought-iron screws and nuts and cast-iron faces ..	17 10 0	21 0 0	27 0 0	31 6 0	54 10 0
Price extra with spigot and socket ends fitted to valves	5 18 0	7 13 0	10 10 0	14 5 0	17 12 0
Price extra fitted with hand wheels on top of spindles ..	0 10 0	0 10 0	..	..	..
Price extra with faced flanges ..	0 10 3	0 13 9	0 17 3	1 0 3	1 3 0

Prices extra if fitted with stuffing boxes, bushed with brass, from 2″ to 6″ valves, 2/3 each.
" " " " " 7″ " 12″ " 3/- "
" " " " " 12″ " 18″ " 3/6 "
" " " " " 20″ " 24″ " 4/- "
" " " " " 30″ " 36″ " 5/- "

Price of keys for opening sluice valves:—bright, 15/- each; rough, 12/- each.

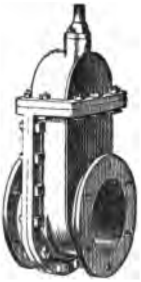

Fig. 435.

DONKIN'S IMPROVED SCREW WATER VALVES, Fig. 435. These valves are proved to 400 feet head of water. The dimensions give the sizes of the valves without allowance for joints. The threads of the screws are made of an improved shape, in order to render them more durable than the ordinary square thread.

If the proportions required differ from those given in the table one shilling per inch diameter is charged for alterations to patterns, but if a number of valves are ordered at the same time from one pattern no charge is made for alteration. The valves with four gun-metal faces are generally used in the best class of work, and are especially necessary for withstanding a high pressure. Also for use with water, which acts injuriously on cast iron.

If the valves are fitted with metallic stuffing boxes which require no packing the cost is increased as follows:—up to 4 in. diameter, 2*s.* per in.; above 4 in. diameter, 1*s.* 6*d.*

The cost of packing for shipment is 5 per cent.

DONKIN'S SCREW WATER VALVES, Fig. 435.

Bore of valve in inches	2	2½	3	4	5
Length from face to face of flanges over all	7½	8	8	10	10
Diameter of flanges	6½	7	8½	10	10½
Diameter of circle through centre of bolt holes	4¾	5¼	6½	8	8½
Number of holes in flanges ..	4	4	4	4	4
Size of holes in flanges	⅝	⅝	$\frac{11}{16}$	$\frac{11}{16}$	¾
Length over ends of sockets ..	9	10	12	13	13
Depth of sockets	2½	2½	3	3¾	4
Per valve, with four gun-metal faces, gun-metal screws and nuts	£2 18 6	£3 7 6	£3 18 0	£5 4 0	£6 10 0
Per valve, with four gun-metal faces, wrought-iron screws and gun-metal nuts	2 15 0	3 3 0	3 9 6	4 11 0	5 14 0
Per valve, with two gun-metal faces, wrought-iron screws and gun-metal nuts	2 12 0	2 18 6	3 1 0	3 18 0	4 17 6

Bore of valve in inches	6	7	8	9	10
Length from face to face of flanges over all	11	11	12	13	13
Diameter of flanges	12	14½	15½	17	18
Diameter of circle through centre of bolt holes	9½	12	13	14	15
Number of holes in flanges ..	6	6	6	6	6
Size of holes in flanges	$\frac{13}{16}$	$\frac{13}{16}$	⅞	1	1
Length over ends of sockets ..	13	14	15	16	17
Depth of sockets	4	4	4¼	4½	4½
Per valve, with four gun-metal faces, gun-metal screws and nuts	£7 16 0	£9 2 0	£10 8 0	£12 5 6	£13 13 0
Per valve, with four gun-metal faces, wrought-iron screws and gun-metal nuts	6 16 6	8 6 0	9 8 6	11 0 6	12 13 6
Per valve, with two gun-metal faces, wrought-iron screws and gun-metal nuts	5 17 0	7 9 6	8 9 0	9 15 0	11 14 0

Bore of valve in inches	12	14	16	18	20	22	24
Length from face to face of flanges over all	14	16	18	19	20	20	21
Diameter of flanges	20	22	26	27	29	31	33
Diameter of circle through centre of bolt holes	17	19	22	23	25	27	29½
Number of holes in flanges ..	6	6	6	6	8	8	8
Size of holes in flanges	1⅛	1¼	1¼	1¼	1¼	1¼	1¼
Length over ends of sockets ..	18	19	20	21	22	23	24
Depth of sockets	5	5	5	5	5	6	6
Per valve, with four gun-metal faces, gun-metal screws and nuts	£17 11 0	..	..	..	..	..	..
Per valve, with four gun-metal faces, wrought-iron screws and gun-metal nuts	15 18 6	..	..	..	..	..	..
Per valve, with two gun-metal faces, wrought-iron screws and gun-metal nuts	14 6 0	..	..	..	..	..	..

WATER METERS, SIEMEN'S AND ADAMSON'S PATENT, Fig. 436. This meter is constructed upon the well-known principle of the Barker's Mill, which has long been in use as a motive power for working mills, and for other purposes. This is the first application of the principle to an instrument for measuring water, which is done without materially diminishing the velocity or the effective pressure. The measuring medium consists of a drum, working on an upright spindle at the bottom, and in a collar at the top. The water is conveyed by the conducting tube into the centre of the drum, and allowed to escape at three or more apertures on the periphery of the same, giving to it a rotary motion. At each revolution of the drum a certain number of cubic inches of water is delivered, so that it is only necessary to register the number of revolutions to ascertain the quantity; this is effected by wheels and pinions, and the result indicated in gallons or feet, upon a graduated scale.

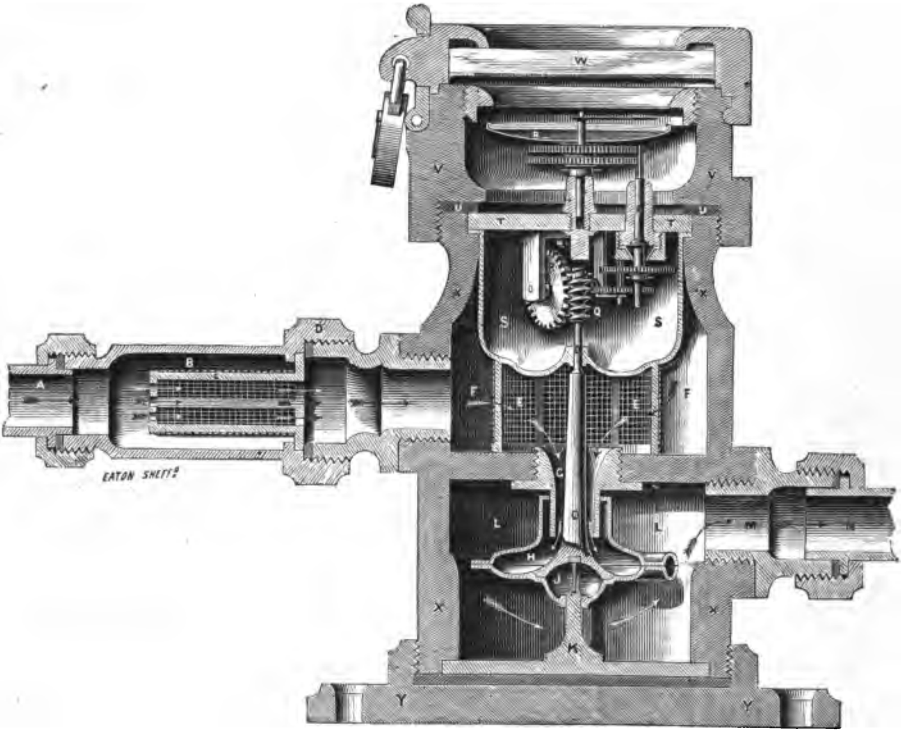

Fig. 436.

The meters are guaranteed to be free from constructional defects and in good working condition when delivered, and may be maintained permanently in working order, or replaced at an annual charge of about 10 per cent. per annum on the cost price, except for repairs due to injuries of an extraneous character arising from violence or exposure to frost, the nature and extent of which cannot be estimated. Water companies usually keep several meters of each size in stock so as to replace any that require examination or repair, rather than allow the water to pass unmeasured during the time the meter may be under repair. Meters having sometimes been damaged by being taken to pieces and improperly put together, the plan of sealing them up has been adopted, so that it shall be evident to the inspector if the seal has been broken.

As meters are required to register the quantity of water passed through them with considerable accuracy, all reasonable precautions should be adopted to obtain this result. The dirt box is intended to prevent foreign matter passing into and injuring them temporarily by weeds, &c., clogging the revolving disc, or permanently by sand cutting the working parts. The meter case affords great facility for examining or, if necessary, changing a meter in a short time, and without disturbing the mains or the surrounding ground.

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PRICES OF METERS AND ACCESSORIES.

Numbers	1	2	3	4	5	6	7	7½	8	9	10	11	12	13	14
Diam. of inlet and outlet in inches	⅜	½	¾	1	1¼	1½	2	2½	3	4	5	6	8	10	12
Gallons delivered per hour at an effective pressure of 50 ft. ..	150	300	600	1,500	2,200	3,000	4,000	6,000	8,300	13,400	18,500	27,000	45,000	70,000	90,000
Ditto 150 ft.	250	500	1,000	2,500	3,800	5,000	7,000	10,000	14,000	23,000	32,000	46,000	77,000	120,000	154,000
Price each with brass filters, and unions tinned, for lead pipe	50/-	61/-	75/-	88/-	111/-	127/-	..	..	..	..	..	..	..	..	..
Price each with flange ends for connecting to cast-iron pipe	..	..	..	88/-	111/-	127/-	153/-	195/-	227/-	299/-	385/-	493/-	718/-	922/-	1254/-
Dirt box, with copper strainer for preventing foreign substances passing through meter, flange ends	..	6/9	8/3	9/6	11/3	12/6	25/-	30/-	33/-	43/-	57/-	75/-	129/-	165/-	218/-
Dial or meter cover for preventing damage to dial .. each	2/-	2/-	2/-	3/4	3/4	3/4	3/4	3/4	3/4	3/4	3/4	3/4	3/4	3/4	3/4
Meter or street cases of such dimensions as admit of the meter being taken out without disturbing the road .. each	26/-	26/-	26/	26/-	26/-	26/-	38/-	38/-	38/-	38/-	56/-	56/-	80/-	..	..
Annual charge of guarantee ..	4/-	5/4	6/8	8/-	10/8	12/-	16/-	20/-	24/-	30/8	40/-	47/-	67/-	90/-	120/-
Spigot and sockets bolted to end of meter and dirt box .. each	..	..	..	6/9	6/9	6/9	7/-	8/6	10/-	13/-	16/-	20/-	30/0	40/-	52/-

Meter, with stand post, sluice cock, and hose screen, for street watering, supplying shipping, flushing sewers, or similar purposes. See Fig. 437.

Meters for supplying water to towns, district mains, or large consumers, should be arranged in duplicate or triplicate.

STREET WATERING APPARATUS, Fig. 437. The meter arrangement, with stand-post for street watering, as shown, has been adopted in many large towns, and from the results obtained may be considered the best arrangement for the purpose.

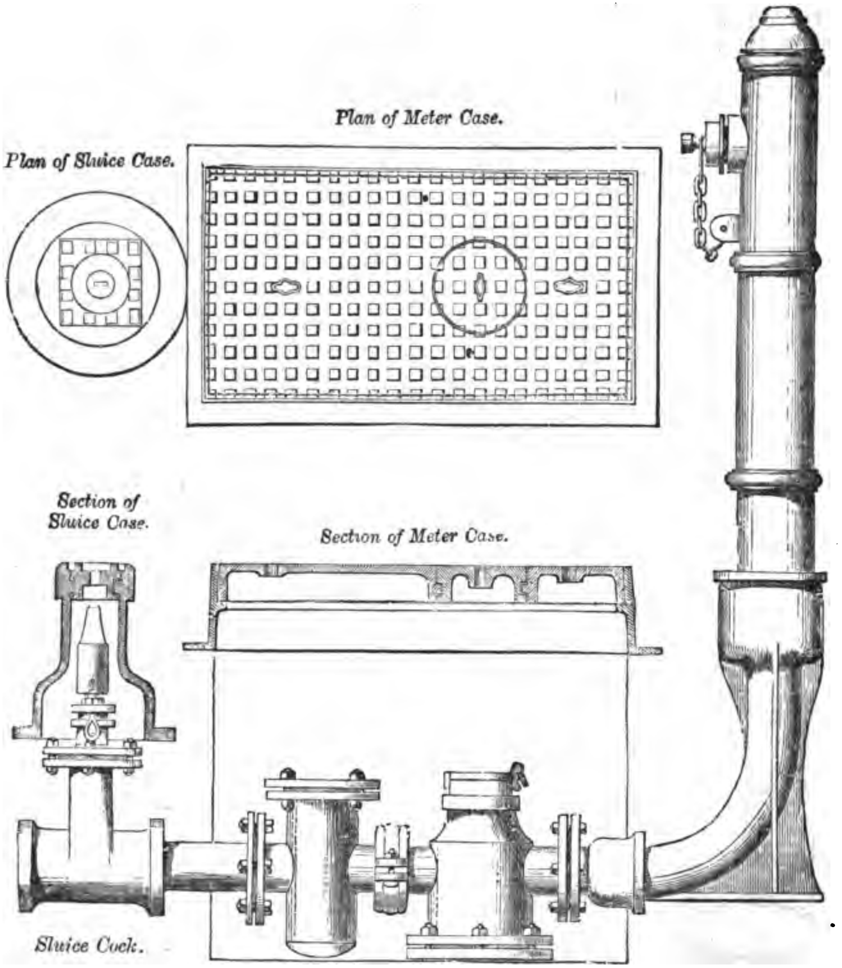


Fig. 437.

Diameter in inches	2	2½	3
Water meter	£7 13 0	£9 15 0	£11 7 0
Dirt box	1 5 0	1 10 0	1 13 0
Dial cover	0 3 4	0 3 4	0 3 4
Sluice cock, with socket ends	1 15 0	2 4 0	2 10 0
Meter case	1 18 0	1 18 0	1 18 0
Sluice case	0 10 0	0 10 0	0 10 0
Stand-post with elbow shoe complete for filling water carts	2 19 0	2 19 0	2 19 0
Spigot and socket, bolted to each end of meter ..	0 7 0	0 8 6	0 10 0

Patent high-pressure strong loose valve stop cocks, with cast-iron bodies, gun-metal working parts, valve, and seat, may be had instead of the sluice cock in the above arrangement, if preferred. It is desirable to place the valve and meters on the footpath, or in such a position that they are not likely to get the street dirt in the boxes.

PATENT HYDRANTS OR FIRE COCKS. One of the many advantages of a constant high-pressure service is that the whole available pressure may be made available almost instantaneously, without waste of water and without the use of fire engines.

The hydrant or fire cock, Fig. 440, is very largely used for this purpose, as well as for watering streets, and for the protection of public buildings, warehouses, mansions, &c., from fire. The hydrant is also used in railway stations for cleaning carriages, washing out engines, boilers, tenders, and many other purposes.

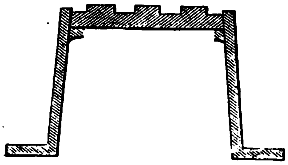


Fig. 439.

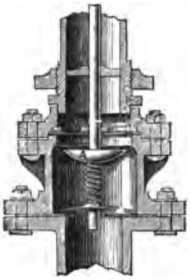


Fig. 441.

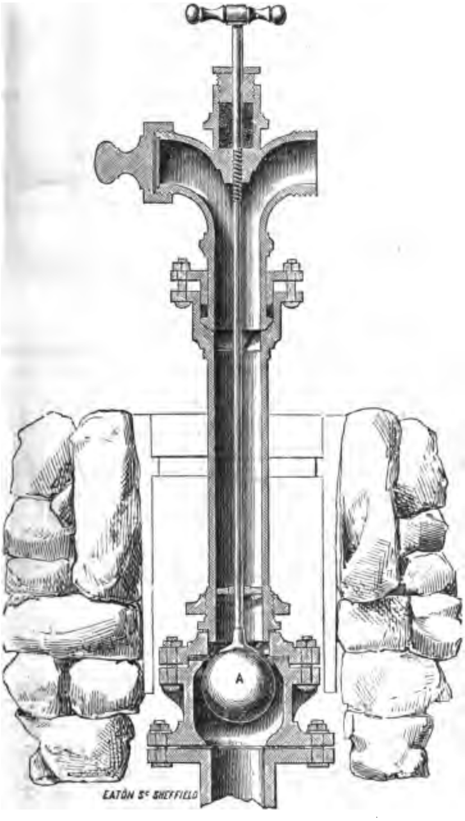


Fig. 440.

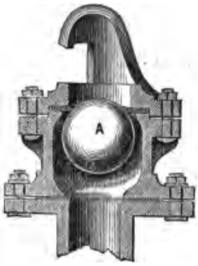


Fig. 442.

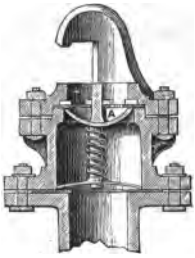


Fig. 443.

The pressure on the valve being upwards, the tendency to keep the valve tight increases in proportion to the pressure or head of water in the pipes.

The **FIRE COCK** consists of a cast-iron box or casing, containing a self-acting valve, closed by the pressure of the water. For street purposes this casing is attached to a vertical branch from the water main, or by an elbow pipe attached to the end of the main, and when not in use the outlet of the valve is closed by a loose cover or stopper, and the whole protected from injury by a cast-iron case (Fig. 439), similar to the ordinary cases or covers for protecting street cocks or fire plugs.

PATENT FIRE COCK, WITH ELBOW PIPE for connecting to the end of 2-, 2½-, and 3-in. pipes. 16*s*. each.

Fig. 443. Sectional view of patent fire cock, with metal disc valve A closed. 16*s*. each.

Fig. 439. Section of cast-iron case or surface box, made of such a size as will allow the cock to be removed or repaired without interfering with the surface of the road. 9*s*. 3*d*. each.

If with chained covers, 10*s*. each.

Fig. 440 represents a vertical section of a 2-in. fire cock and copper stand-pipe, attached to the fire cock and ready for use.

The valve A consists of a solid gutta-percha ball, or other elastic substance of less specific gravity than water, and closed by the pressure of the water against a vulcanized india-rubber seating.

Price, suitable for hydrants, Figs. 440, 442, and 443, with gun-metal mountings and double revolving discharge outlets, screwed to any size threads, £4.

If with single discharge outlet, £3 4*s*.

Fig. 441. The valve A is a metal disc, against a leather or india-rubber seating, kept tight by the pressure of the water. The helical spring shown in the engraving is introduced merely to prevent the valve dropping when there is no water or pressure in the mains.

The valve is opened by a detached key or stand-pipe, similar to Fig. 440 attached to the fire cock, and the prices are the same.

Fig. 442. Sectional view of patent fire cock, showing the ball valve A closed, and one of the inverted L-shaped lugs under which the projecting pins at the bottom of the stand-pipe pass when affixed for use. 10*s*. each.

HIGH-PRESSURE LOOSE VALVE GLOBE BARREL FIRE COCK, Fig. 444, is made of best gun metal. 2½ in. Rough, 62*s*.; finished, 72*s*. each.

Ditto, with cast-iron bodies, and brass working parts, and gun-metal hose screw, 2½ in., rough, 48*s*.

Caps for these cocks in gun metal, 10*s*. 6*d*. each.

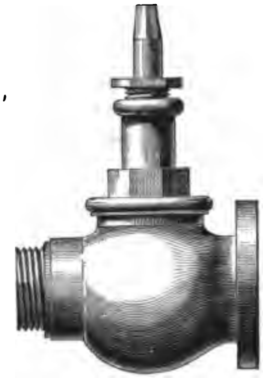


Fig. 444.

LEATHER FIRE BUCKETS, large size, holding about three gallons, with best sewn top and covered iron rim, 15*s*. each.

Ditto, ordnance pattern, with copper rim, and smaller, 13*s*. 6*d*. each.

CANVAS FIRE BUCKETS, 4*s*. 6*d*. each.

GALVANIZED IRON BUCKETS, 3*s*. 6*d*. each.

SCREWED COVERS for Fire Cocks, Figs. 442 and 443, to prevent them being damaged, 6*s*. each.

GUTTA-PERCHA RINGS OR WASHERS for the joints of Fire Cocks with the mains, 5*s*. 6*d*. per dozen.

BRANCH PIPES. See Fig. 453.

SPREADERS. See Fig. 454.

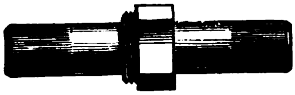


Fig. 445.

STRONG GUN-METAL UNION JOINTS, Fig. 445, for lead pipe.

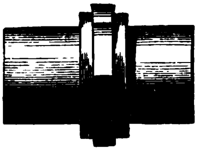
Diam. in inches ..	½	⅝	¾	⅞	1	1¼	1½	1¾	2
Price per pair ..	1/4	1/6	2/1	2/5	2/8	4/3	5/–	6/–	7/6

Fig. 446.

STRONG GUN-METAL UNION JOINTS, Fig. 446, one end screwed for iron pipe and the other tinned for lead pipe.

Diam. in inches ..	½	¾	1	1¼	1½	2
Price per pair	1/10	2/8	3/9	5/–	6/3	9/–

Fig. 447.



GUN-METAL UNIONS, Fig. 447, suitable for wrought-iron tube.

Diam. in inches ..	½	¾	1	1¼	1½	2
Price per pair ..	1/6	2/-	2/9	4/-	5/-	8/-

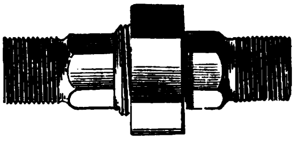
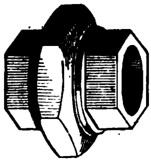


Fig. 448.

STRONG GUN-METAL UNIONS, Fig. 448, for steam, and screwed at both ends for wrought-iron tube.

Diam. in inches ..	½	¾	1	1¼	1½	2
Price per pair ..	1/10	2/8	3/9	5/-	6/3	9/-

Fig. 449.



GUN-METAL UNIONS, Fig. 449, for steam, screwed inside at both ends.

Diam. in inches ..	½	¾	1	1¼	1½	2
Price per pair ..	2/3	3/-	4/-	5/6	7/9	12/-

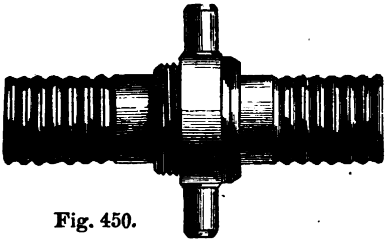


Fig. 450.

STRONG GUN-METAL SERVICE HOSE SCREWS, Fig. 450.

Diam. in inches ..	1	1¼	1½	1¾	2	2½	3
Price per pair ..	3/6	5/6	6/6	8/-	9/6	14/-	21/-

The 2½ inch are made to the London Fire Brigade gauge.

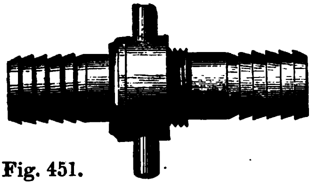


Fig. 451.

LIGHT GUN-METAL SERVICE UNION HOSE SCREWS, Fig. 451, for connecting rubber or canvas pipe.

Diam. in inches	½	⅝	¾	1	1¼	1½	1¾	2	2½
Price per pair ..	1	1/3	1/8	2/5	4/6	5/6	6/4	8/-	10/6

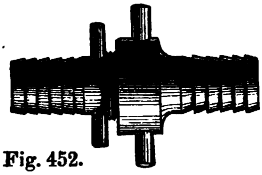


Fig. 452.

GUN-METAL HOSE SCREWS, Fig. 452.

Diam. in inches ..	1	1¼	1½	1¾	2	2½	3
Price per pair ..	2/8	3/9	5/-	6/3	7/3	12/-	17/-

HALF UNIONS WITH SWIVEL SCREWED, for wrought-iron tube, the other end suitable for hose or tinned for lead pipe.

Diameter in inches	1	1¼	1½	2	..	..	..
Price, each	1/6	2/-	4/-	5/6	..	..	..

BINDING HOSE SCREWS, with copper wire.

Diameter in inches	1	1¼	1½	1¾	2	2½	3
Price per pair	1/-	1/3	1/6	1/9	2/-	2/6	3/-

Fig. 453.

STRONG TAPER COPPER BRANCH PIPES, Fig. 453, with gun-metal nozzles and male screw for hose.

Diam. in inches, suitable for hose	1¼	1½	1¾	2	2½	3
Price, each	15/–	16/6	18/–	£1 1 6	£1 4 0	£1 7 6

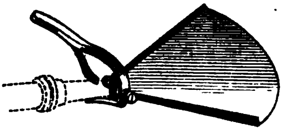


Fig. 454.

GUN-METAL SPREADERS, Fig. 454, to attach to copper branch pipes.

Size	1¼	1½	1¾	2
Price, each	2/3	2/9	3/4	4/–

COPPER SUCTION ROSES, Fig. 455.

Diam. in inches, suitable for hose ..	1½	1¾	2	2½	3
Price per foot	4/9	5/6	6/6	8/3	9/9

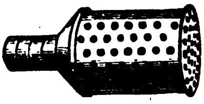


Fig. 455.

PUMP FITTINGS.

Iron well rod, with brass couplings and joints every 12 feet.

Diameter in inch of rod	⅝	¾	⅞	1
Price per foot	0/8	0/9	1/2	1/4

Brass couplings only, ⅝, 1/0; ¾, 1/1 each.

Brass coupling with iron joint.

Diameter in inch of rod	⅝	¾	⅞	1
Price, each	3/2	4/2	5/3	7/6

ROLLER GUIDES, Fig. 456.

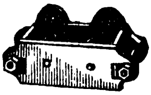


Fig. 456.

Diam. in inch of well rod	⅝	¾	⅞	1
Price, each, single ..	3/6	3/6	5/6	8/0
„ double ..	10/6	10/6	12/6	15/0
„ treble ..	15/0	15/0	17/6	19/6

CAST-IRON WELL STAGES, Fig. 457, including roller guides and supports for pipe, 4 ft. 6 in. long:—Price, each, for single pump, £1 7*s*. 6*d*.; ditto, double pump, £1 12*s*. 6*d*.; ditto, treble pump, £1 19*s*.

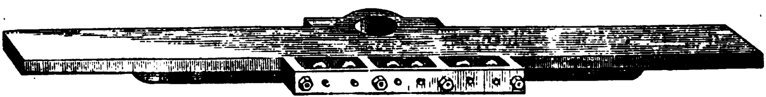


Fig. 457.

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CAST-IRON WELL STAGES, for supporting pump barrels, 4 ft. 6 in. long.

Price, each, for single pump, £1 8*s*. 6*d*.; ditto, for double pump, £1 10*s*. 6*d*.; ditto, for treble pump, £1 14*s*. 9*d*.

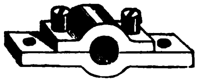


Fig. 458.

WELL ROD BRASSES, Fig. 458, 4*s*. 3*d*. per pair.

COPPER AIR VESSELS for deep-well pumps, &c. These should be supplied wherever a great length of rising main is required, as they assist in keeping up a continuous supply of water and reduce concussion in the pipe.

Price, each, for 2½-in. and 3-in. pumps,	£1 5 6;	extra strong,	£1 17 6
„ „ 3½ „ 4 „	1 10 0	„	2 0 0

CAST-IRON AIR VESSELS, with copper dip pipe and flange.

Price, each, for 2½-in and 3-in. pumps,	£1 3 0
„ „ 3½ „ 4 „	1 7 6

HORIZONTAL SHAFTING, WITH PLUMMER BLOCKS AND JOINTS, for working pump at a moderate distance from well.

Price for 7 ft. of 1¾ in, shaft, with two lever ends, plummer blocks and brasses, £3 3*s*.
Price extra per foot additional, 2*s*. 9*d*.

WROUGHT-IRON BELL CRANK MOTION, for deep-well pump, with wrought-iron joints, trunnion, and two plummer blocks, with gun-metal bearings, with arms and joints for shutting to rod.

Price, 1½ in., £2 10*s*.; 1¾ in., £3 each.

PUMP HANDLES, wrought-iron, straight, with carriage and brass bearings, slings, copper guide rod cross-piece.

Size of pump barrel in inches ..	2	2½	3	3½	4
Price each of moderate strength	£1 3 0	£1 8 0	£1 11 6	£1 14 0	£1 19 0
„ strong	1 11 0	1 13 0	1 16 0	2 0 0	2 5 0

WROUGHT-IRON JACK PUMP HANDLES.

Size of pump barrel in inches ..	2½	3	3½	4
Price, each	£0 3 9	£0 4 2	£0 6 2	£0 8 3
„ with brass bearings ..	0 8 2	0 9 9	0 11 6	0 14 6

BRASS STUFFING BOX AND FLANGE FOR PUMPS.

Size of pump barrel in inches ..	2	2½	3	3½	4
Price, each	£0 10 0	£0 13 0	£0 16 0	£0 19 0	£1 0 0

BRASS STUFFING BOX AND AIR CHAMBER, on one flange, with copper screws for pumps.

Size of pump barrel in inches ..	2½	3	3½	4
Price, each	£1 4 6	£1 9 6	£1 14 0	£2 1 0

BRASS AIR CHAMBER AND FLANGE, with clack and screws for pumps.

Size in inches	2	2½	3	3½	4
Price, each	£0 7 9	£0 9 6	£0 12 3	£0 15 0	£0 18 0

BRASS AIR CHAMBER AND TAIL PIPE, with clacks and screws for pumps.

Diameter in inches for pumps ..	2	2½	3	3½	4
Price, each	£0 8 6	£0 11 6	£0 13 9	£0 17 0	£1 0 0
„ for tail pipe and flange only	0 6 9	0 8 0	0 10 6	0 14 0	0 17 0

CAST-IRON FOOT VALVES, suitable for wrought-iron tube or cast-iron flanged pipe.

Diameter in inches ..	1	1¼	1½	1¾	2	2½	3	4
Price, each	£0 6 3	£0 7 6	£0 10 0	£0 12 6	£0 15 0	£0 18 6	£1 4 0	£1 14 0

Diameter in inches ..	5	6	7	8	9	10	11	12
Price, each	£2 8 0	£3 12 0	£4 0 0	£4 15 0	£5 10 0	£6 0 0	£7 0 0	£8 0 0

CAST-IRON RETAINING VALVE, for vertical pipe.

Size in inches ..	2	2½	3	4	5	6
Price, each	£0 18 6	£1 4 6	£1 16 0	£2 7 0	£3 10 0	4 5 0

BRASS BUCKET, leathered.

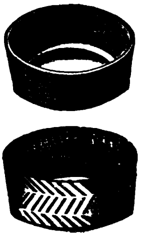
Diameter in inches ..	2	2½	3	3½	4	5	6
Price, each, light ..	£0 3 0	£0 4 0	£0 5 6	£0 7 6	£0 9 6	..	.
„ strong ..	0 4 0	0 5 6	0 7 0	0 8 6	0 10 6	1 2 0	1 12 0

BRASS SUCKER BOX.

Diameter in inches ..	2½	3	3½	4	4½	5
Price, each	£0 3 9	£0 4 8	£0 5 0	£0 7 6	£0 9 6	£0 11 0

WOOD BUCKETS AND SUCKERS.

Diameter in inches	2½	3	3½	4	4½	5	5½	6
Price of buckets per dozen ..	5/3	7/-	8/3	10/-	14/-	15/-	17/6	21/-
„ suckers	1/6	1/10	2/3	3/	4/9	6/6	7/-	8/-


Figs. 459, 460.

CUP LEATHERS FOR PUMPS, Figs. 459 and 460.

Diameter in inches	2	2½	3	3½	4	5	6
Price, for buckets .. .. .. each	-/9	-/10	1/1	1/4	1/8	2/4	3/6
„ solid bottoms for plungers „	-/10	1/-	1/3	1/6	1/9	2/6	3/6
„ quilted cups for hot liquor pumps .. .. each	-/10	1/3	1/6	1/7	1/9	2/6	3/6
Quilting for hot liquor pumps, width ..	1¼	1½	1¾	2	2½	3	..
Price per yard	1/6	1/9	1/10	2/6	2/8	3/-	..

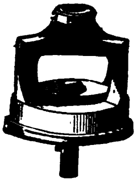


Fig. 461.

STRONG BRASS PUMP BUCKETS, WITH METAL VALVES, Fig. 461.

Diameter in inches ..	1½	2	2½	3	3½	4	4½
Price	6/-	7/6	8/6	11/6	16/6	19/-	28/-

COPPER PUMP ROD, with two brass nuts for pumps.

For pumps, diameter in inches	2	2½	3	3½	4
Price, each..	4/-	4/4	4/10	6/-	6/4

COPPER PUMP SCREWS.

Square heads, 2 in. to 4 in., 6/- per doz; round heads, 5/- per doz.

COPPER PUMP PIPES, for deep wells, tinned all over, with collared joints, very light, strong and durable, and perfectly pure.

Diameter in inches	1¼	1½	2	2½	3	3½	4
Price per foot	1/8	1/10	2/8	3/6	5/-	6/-	7/6

Elbows for ditto, price extra per foot, up to 2 in. 9*d*., 2½ in. and above, 1/3.

CONNECTING FLANGES, for copper pipe, with leather flange and screws.

Diameter in inches of pipe.. ..	1¼	1½	1¾	2	2½	3
Price, each	6/9	7/3	8/0	9/0	11/0	12/6

PATENT LEAD ENCASED BLOCK TIN PIPE. This pipe is perfectly wholesome, and free from the poisoning qualities of common lead; it is lighter, of equal strength and ease in working, and less liable to burst from the action of the frost. The price fluctuates according to the market value of lead and tin, and the subjoined list is based on the present cost of this pipe, viz., 40*s*. per cwt.

Internal diameter in inches		½	⅝	¾	1	1¼	1½	2
Average length of coils, light ..	yards	32	26	36	27	22	17	12
„ weight per yard ..	lbs.	3½	4½	5½	7¼	9	11	16
Price per yard	..	1/4	1/8	2/1	2/9	3/5	4/1	6/-
Average length of coils, medium	yards	28	37	33	25	19	15	12
„ weight per yard ..	lbs.	4	5¼	6	8	10	12	18½
Price per yard	...	1/6	2/-	2/3	3/-	3/9	4/6	7/-
Average length of coils, strong ..	yards	25	33	28	22	16	14	12
„ weight per yard ..	lbs.	4½	6	7	9	12	14	21
Price per yard	..	1/8	2/3	2/8	3/5	4/6	5/3	7/10

LEAD PUMP PIPES are made of various strengths, and the price is governed by the market value of lead. The cost per foot or for any length can readily be ascertained from the following table of weights, the present price being about 22*s*. per cwt.

PRICE OF LEAD PUMP PIPES.

Internal diam. in inches ..	½	⅝
Weight per 15 ft. lengths ..	15, 18, 22, 25, 28 & 30 lbs.	18, 22 & 27 lbs.

Internal diam. in inches ..	¾	1
Weight per 15 ft. lengths ..	22, 24, 26, 28, 32, 36 & 45 lbs.	28, 36, 42, 48 & 54 lbs.

The above sizes are usually made in coils, 60 feet long.

Internal diam. in inches	1¼	1½
Weight per 12 ft. lengths	36, 42, 48, 52 & 61 lbs.	42, 50, 56, 72 & 84 lbs.

The above sizes are made in coils of 36 feet long.

Internal diam. in inches	1¾	2	2½	3
Weight per 12 ft. lengths	70, 84, 96	84, 96, 112	126	108
„ „ 10 ft. „	..	..	120	120, 150

Internal diam. in inches ..	3½	4	4½	5	6
Weight per 10 ft. lengths ..	135, 150, 184	135, 160, 200	200, 216, 234	234, 254, 280	330 lbs.

WROUGHT-IRON PIPES, Fig. 462, with wrought or cast-iron flanges truly faced and bolt holes drilled to template, are suitable for use in any situation where extreme lightness is desirable, such as in sinking pumps, for overland transport, centrifugal pumps for irrigation, &c.

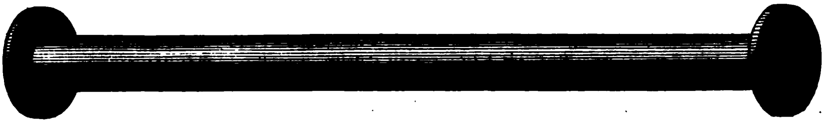


Fig. 462.

PRICES OF WROUGHT-IRON WELDED PIPES, Fig. 462.

Internal diam. in inches ..	5	6	7	8	9
Price per 3 ft. lengths	£2 5 0	£2 8 0	£3 3 0	£3 7 0	£4 5 6
„ 6 „	2 16 6	3 2 0	4 2 0	4 10 0	6 3 6
„ 9 „	3 4 0	3 11 6	4 14 6	5 5 0	7 8 6

WROUGHT-IRON RIVETTED PIPES, Fig. 463. These pipes are used for similar purposes to those last referred to, they are not so light but will stand rougher usage, and for this reason are suitable for all kinds of contractors' work as well as for mining purposes. These pipes are made with rivetted lap joints longitudinally, and butt joints, and cover plate at centre. The flanges for the smaller sizes are formed of stout angle iron rings welded up and rivetted to the pipe and faced. The larger sizes have flanges of cast iron. The accessories used in connection with these pipes are sliding or telescopic suction pipe, ball and socket gland joints for carrying suction or delivery pipes at an angle, universal jointed bends or goose necks, constructed in single or double bends—the single bend is fitted with a flanged gland, so that the bend can

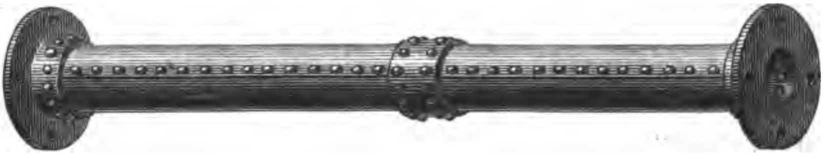


Fig. 463

be turned to deliver in any direction—the double bend is fitted with a gland at the junction of the two bends so that they can be placed in any position relatively to each other. The cost of these will be found below.

PRICES OF WROUGHT-IRON RIVETTED PIPES, Fig. 463.

Internal diam. in inches..	5	6	7	8
Price, 6 ft. length, each	£1 10 0	£2 2 0	£2 10 0	£3 5 0
„ 9 „ „	2 5 0	3 3 0	3 15 0	4 10 0
„ of sliding or telescopic suction pipes to slide 5 ft., each	13 5 0	19 0 0	23 0 0	26 10 0
Price, suction pipes to slide 8 ft., each..	16 0 0	22 10 0	27 10 0	31 0 0
„ of ball and socket joint	9 2 6	11 0 0	12 10 0	14 0 0
„ of universal bends, single ..	7 0 0	8 10 0	10 10 0	12 5 0
„ „ „ double ..	9 0 0	10 0 0	11 10 0	13 10 0

Internal diam. in inches	9	10	12
Price, 6 ft. length, each..	£4 5 0	5 15 0	£8 0 0
„ 9 „ „	5 15 0	8 5 0	11 10 0
„ of sliding or telescopic suction pipes to slide 5 ft., each	30 0 0	35 0 0	44 0 0
Price of suction pipes to slide 8 ft., each	36 10 0	42 10 0	53 0 0
„ of ball and socket joint	16 0 0	18 10 0	22 0 0
„ of universal bends, single	14 0 0	16 0 0	19 0 0
„ „ „ double	15 10 0	18 0 0	22 0 0

LEATHER DELIVERY AND SUCTION HOSES.

COPPER RIVETTED DELIVERY HOSE, to stand a pressure of from 80 to 100 lbs. per square inch.

Diam. in inches ..	1	1½	1¾	2	2¼	2½	2¾	3
Price per foot ..	£0 1 5	£0 1 9	£0 2 0	£0 2 2	£0 2 4	£0 2 7	£0 3 0	£0 3 4

COPPER RIVETTED DELIVERY HOSE, for steam fire engines, to stand a pressure of from 120 to 150 lbs. per square inch. The prices include hand loops and straps.

Diam. in inches ..	2	2¼	2½	2¾	3	3½	4
Price per foot ..	£0 2 6	£0 2 9	£0 3 0	£0 3 3	£0 3 6	£0 3 9	£0 4 5

COPPER RIVETTED SUCTION HOSE, equal in strength to 4-ply india-rubber suction hose.

Diam. in inches ..	1½	1¾	2	2¼	2½	2¾	3	3½	4
Price per foot ..	£0 3 9	£0 3 11	£0 4 1	£0 4 5	£0 4 11	£0 5 3	£0 5 9	£0 6 5	£0 7 3

FLEXIBLE SUCTION HOSE, bound with copper wire outside, equal in strength to 3-ply india-rubber suction hose.

Diam. in inches ..	1½	1¾	2	2¼	2½	2¾	3
Price per foot ..	£0 3 3	£0 3 4	£0 3 5	£0 3 8	£0 4 0	£0 4 5	£0 4 9

COPPER RIVETTED SUCTION HOSE, with copper spiral wire inside, made very strong and durable.

Diam. in inches	1½	1¾	2	2¼	2½	2¾	3	3½	4
Price per foot ..	£0 5 9	£0 6 5	£0 7 0	£0 7 10	£0 8 5	£0 9 7	£0 10 6	£0 12 5	£0 14 9

CRANE PIPES OR HOSES, for water cranes.

Diam. in inches ..	4	5	6	7	8	9	10
Price per foot ..	£0 3 11	£0 4 8	£0 5 6	£0 6 4	£0 7 1	£0 7 11	£0 8 9

CANVAS SUCTION HOSE, 3-ply and waterproofed, with special composition.

Diam. in inches ..	1½	1¾	2	2¼	2½	3
Price per foot ..	£0 1 8	£0 1 11	£0 2 2	£0 2 6	£0 2 9	£0 3 4

WOVEN CANVAS HOSE (Voucher's Patent), made without seam, is watertight, resisting the pressure of the most powerful force pump; and is made of any diameter or length desired. This hose is suitable for use in tropical climates, no special care being required for its preservation, and it is not injured by exposure to the sun.

Diam. in inches ..	1	1¼	1½	1¾	2	2⅛	2¼	2½	2⅝	3
Price per foot ..	-/9	-/10	-/11	1/-	1/1	1/2	1/3	1/3½	1/4½	1/6½

WOVEN CANVAS HOSE, of ordinary quality.

Diam. in inches	½	¾	1	1¼	1½	1¾	2	2¼	2½	2¾	3	3½
Price per foot ..	-/3½	-/4	-/5	-/6	-/7	-/9	-/10	-/11	1/-	1/1	1/2	1/4

This hose can be burnetized at 3*d*. per yard extra, and can be made any size up to 10 inches diameter.

VULCANIZED INDIA-RUBBER AND CANVAS HOSE. The best quality is made of best rubber and cotton for conducting delivery, in 60 feet lengths. One-ply is not intended to work with much pressure; 2-ply will stand 30 lbs., 3-ply 75 lbs., and 4-ply 175 lbs. water pressure, per square inch, for hose 1 inch diameter.

Diam. in inches	¼	⅜	½	⅝	¾	⅞	1	1¼	1½
Price per ft., 1-ply	£0 0 5	£0 0 5	£0 0 6	£0 0 7	£0 0 8	£0 0 9	£0 0 11	£0 1 1	£0 1 · 3
„ „ 2 „	0 0 6	0 0 7	0 0 8	0 0 9	0 0 10	0 0 11	0 1 1	0 1 3	0 1 5½
„ „ 3 „	0 0 8	0 0 9	0 0 10	0 0 11	0 1 1	0 1 3	0 1 5	0 1 7	0 1 10
„ „ 4 „	0 0 11	0 1 0	0 1 1	0 1 3	0 1 9	0 1 8	0 1 10	0 2 1	0 2 4

Diam. in inches	1¾	2	2¼	2½	2¾	3	3¼	3½	3¾	4
Price per ft., 1-ply	£0 1 5	£0 1 7	£0 1 9	£0 1 11	£0 2 1	£0 2 3	..	..	..	..
„ „ 2 „	0 1 8	0 1 10½	0 2 1	0 2 3	0 2 5½	0 2 8	..	..	..	..
„ „ 3 „	0 2 0	0 2 3	0 2 6	0 2 9	0 3 0	0 3 3	£0 3 6	£0 3 9	£0 4 3	£0 4 7
„ „ 4 „	0 2 7	0 2 10	0 3 2	0 3 6	0 3 10	0 4 2	0 4 6	0 4.10	0 5 3	0 5 7

INDIA-RUBBER FIRE ENGINE HOSE.

Internal diameter in inches ..	2	2¼	2½	3
Price per foot, 4-ply	£0 3 4	£0 3 6	..	..
„ „ 6 „	..	..	£0 4 2	£0 5 0

VULCANIZED INDIA-RUBBER AND CANVAS SUCTION HOSE, with spiral wire inside, suitable for pumps, locomotives and fire engines.

Diam. in inches	¼	⅜	½	⅝	¾	⅞	1	1¼	1½
Price per ft., 1-ply	£0 0 6	£0 0 7	£0 0 8	£0 0 9	£0 0 11	£0 1 0	£0 1 2	£0 1 5	£0 1 7
" " 2 "	0 0 7	0 0 8	0 0 10	0 1 0	0 1 2	0 1 3	0 1 4½	0 1 8	0 1 10½
" " 3 "	0 0 9	0 0 10	0 1 1	0 1 2	0 1 4	0 1 6	0 1 8	0 1 11	0 2 2
" " 4 "	0 1 0	0 1 2	0 1 4	0 1 6	0 1 9	0 2 0	0 2 2	0 2 5	0 2 8
" " 5 "	0 1 4	0 1 6	0 1 8	0 1 10	0 2 2	0 2 5	0 2 8	0 2 11	0 3 3
" " 6 "	0 1 9	0 1 11	0 2 2	0 2 5	0 2 8	0 2 11	0 3 2	0 3 8	0 4 1

Diam. in inches	1¾	2	2¼	2½	2¾	3	3¼	3½	3¾	4
Price per ft., 1-ply	£0 1 10	£0 2 1	£0 2 4	£0 2 7	£0 2 10	£0 3 1	£0 3 4	£0 3 8	£0 4 0	£0 4 4
" " 2 "	0 2 2	0 2 5	0 2 9	0 3 1	0 3 5	0 3 9	0 4 1	0 4 5	0 4 9	0 5 4
" " 3 "	0 2 5	0 2 9	0 3 1	0 3 5	0 3 9	0 4 2	0 4 7	0 5 0	0 5 5	0 5 10
" " 4 "	0 3 0	0 3 4	0 3 10	0 4 3	0 4 8	0 5 1	0 5 6	0 6 0	0 6 7	0 7 1
" " 5 "	0 3 8	0 4 1	0 4 7	0 5 0	0 5 5	0 5 10	0 6 4	0 6 10	0 7 6	0 8 2
" " 6 "	0 4 6	0 4 11	0 5 4	0 5 9	0 6 4	0 6 10	0 7 5	0 8 1	0 8 10	0 9 6

VULCANIZED INDIA-RUBBER AND CANVAS SUCTION HOSE, with embedded wire for steam, hot water, acids, &c.

Diameter in inches	½	⅝	¾	1	1¼	1½	1¾	2	2¼	2½	3	3½	4
Price per ft., 3-ply	1/10	2/–	2/2	2/6	2/10	3/1	3/6	4/–	4/8	5/2	6/3	7/6	9/–
" " 4 "	2/–	2/2	2/7	2/11	3/2	3/6	4/–	4/7	5/3	5/10	7/3	8/9	10/3

SOCKET PIPES FOR WATER OR GAS. These pipes are tested before leaving the works. ¾ and 1 inch to 200 feet, and 1½ inch and above to 300 feet, of water pressure.

Internal diameter in inches	¾	1	1	1	1¼	1½
Length of pipe, exclusive of faucet, in ft.	4½	4½	4½	6	6	6
Average weight of pipe cwts.	0 0 14	0 0 16	0 0 20	0 0 22	0 0 26	0 1 2
Price per ton	£9 0 0	£8 10 0	£8 10 0	£8 10 0	£7 15 0	£7 0 0
" per yard	0 0 9	0 0 10	0 1 1	0 0 10	0 0 11	0 1 0

Internal diameter in inches	1½	1¾	2	2	2	2
Length of pipe, exclusive of faucet, in ft.	6	6	6	6	6	6
Average weight of pipe cwts.	0 1 7	0 1 8	0 1 14	0 1 22	0 2 0	0 2 6
Price per ton	£7 0 0	£7 0 0	£6 12 6	£6 12 6	£6 12 6	£6 12 6
" per yard	0 1 1	0 1 2	0 1 3	0 1 3	0 1 8	0 1 10

Internal diameter, in inches	2½	2½	2½	2½	3
Length of pipe, exclusive of faucet, in ft.	6	9	9	9	9
Average weight of pipe cwts.	0 2 0	0 3 0	0 3 7	0 3 21	0 3 14
Price per ton	£6 10 0	£6 10 0	£6 7 6	£6 7 6	£6 7 6
" per yard	0 1 7	0 1 8	0 1 9	0 2 0	0 1 11

Socket Pipes for Water or Gas—*continued.*

Internal diameter in inches	3	3	3	3½	4
Length of pipe, exclusive of faucet, in feet ..	9	9	9	9	9
Average weight of pipe, cwts.	0 3 21	1 0 0	1 0 10	1 0 14	1 1 21
Price per ton	£6 5 0	£6 5 0	£6 5 0	£6 5 0	£6 2 6
„ per yard	0 2 0	0 2 1	0 2 3	0 2 5	0 2 10

Internal diameter in inches	4	4½	5	5	6
Length of pipe, exclusive of faucet, in feet	9	9	9	9	9
Average weight of pipe, cwts.	1 2 7	1 2 12	1 3 14	2 0 0	2 1 14
Price per ton	£6 2 6	£6 2 6	£6 0 0	£6 0 0	£6 0 0
„ per yard	0 2 11	0 3 3	0 3 9	0 4 0	0 4 9

CONNECTIONS FOR GAS AND WATER PIPES.

Bends, tees, branches, water traps, &c.,	¾ in. to 1¼ in.	14*s.* 6*d.*	per cwt.
„ „ „	1½ „ to 2 „	12*s.* 6*d.*	„
„ „ „	2½ „ to 6 „	10*s.* 6*d.*	„

Price of pipes, if coated with Dr. Smith's patent solution, 9 ft. lengths, 6*s.* extra; 6 ft. lengths, 7*s.* 6*d.* extra; connections 10*s.* per ton extra.

SOCKET PIPES, WITH TURNED AND BORED POINTS, for water or gas.

Internal diameter in inches	1	1½	2	2½	2½
Length of pipe, exclusive of faucet, in feet	6	6	6	6	6
Average weight of pipe, cwts. ..	0 1 0	0 1 7	0 1 20	0 2 2	0 2 8
Price per ton	£9 7 6	£7 15 0	£7 7 6	£7 5 0	£7 5 0
„ per yard	0 1 2	0 1 3	0 1 7	0 1 10	0 2 0

Internal diameter in inches	2½	3	3	3½	4
Length of pipe, exclusive of faucet, in feet	9	9	9	9	9
Average weight of pipe, cwts. ..	0 3 12	0 3 21	1 0 12	1 0 20	1 1 18
Price per ton	£7 2 6	£6 17 6	£6 17 6	£6 17 6	£6 12 6
„ per yard	0 2 1	0 2 2	0 2 7	0 2 9	0 3 1

Internal diameter in inches	4	4½	5	5	6
Length of pipe, exclusive of faucet, in feet	9	9	9	9	9
Average weight of pipe, cwts. ..	1 2 21	1 2 21	1 3 21	2 0 7	2 1 21
Price per ton	£6 12 6	£6 12 6	£6 10 0	£6 10 0	£6 10 0
„ per yard	0 3 9	0 3 9	0 4 3	0 4 6	0 5 4

WATER TRAPS, mounted.

13½ in. deep by	8 in. wide,	¾ ln. to 2½ in.	16*s.* 6*d.* each.
17 „ „	10 „	3 „ 4½ „	£1 4*s.* 0*d.* „
25 „ „	14 „	5 „ 6 „	£2 9*s.* 0*d.* „

FLANGED PIPES.

Internal diameter in inches ..	1½	2	2½	2½	3	3
Length of pipe, exclusive of faucet, in feet	6	6	6	9	9	9
Average weight of pipe, cwts.	0 1 4	0 1 16	0 2 11	0 3 15	1 0 0	1 1 4
Price per ton	£9 5 0	£8 12 6	£8 5 0	£8 0 0	£7 15 0	£7 15 0
„ per yard	0 1 4	0 1 8	0 2 6	0 2 4	0 2 7	0 3 4

Internal diameter in inches ..	3½	4	5	6	6
Length of pipe, exclusive of faucet, in feet	9	9	9	9	9
Average weight of pipe, cwts.	1 0 21	1 1 16	2 0 14	2 2 7	2 3 0
Price per ton	£7 15 0	£7 15 0	£7 12 6	£7 12 6	£7 12 6
„ per yard	0 3 1	0 3 7	0 5 5	0 6 6	0 7 0

CONNECTIONS FOR FLANGED PIPES.

Bends, branches, tees, &c., 1½ to 2 in. at 12*s*. 6*d*. per cwt.
„ „ „ 2½ „ 6 in. „ 10*s*. 6*d*. „

TURNING OR FACING FLANGES. 1½ to 2 in. at 6*d*.; 2½ to 4½ at 1*s*.; 5 to 6 in. at 1*s*. 6*d*., per pipe or connection.

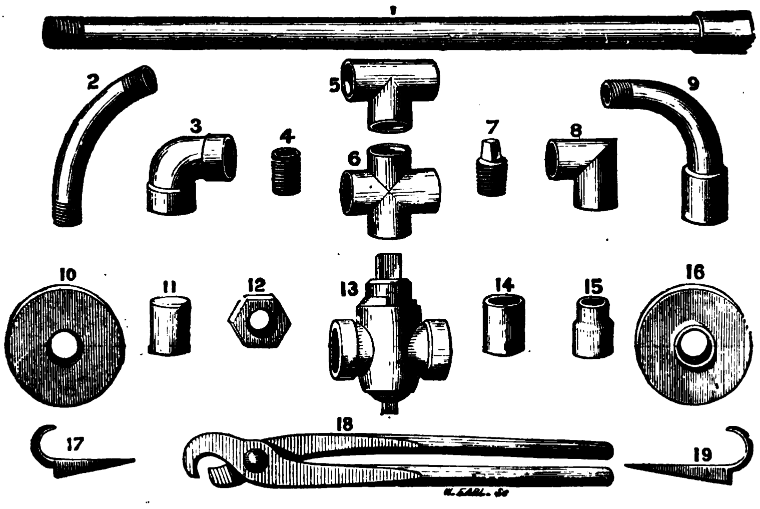


Fig. 464.

WROUGHT-IRON TUBES AND CONNECTIONS FOR GAS, STEAM, OR WATER. Fig. 464, References Nos. 1 to 19.

The tubes referred in Fig. 464, and in the accompanying list, are intended for conveying gas, steam, water, or any other fluid which does not act injuriously on wrought iron. In estimating the cost of such pipes and connections, it should be borne in mind that the prices of piping for pressures exceeding 50 lbs. per square inch are higher than for ordinary gas pipe. When the discount (which varies according to the price of iron) is 50 per cent. off gas piping, the discount off steam piping is 34 per cent. So many varieties of reducing tees, elbows, and sockets are made that it would be impossible to tabulate them, but the prices may be taken as the same as ordinary connections of the largest of the outlets.

PRICES, &c., OF WROUGHT-IRON TUBES AND CONNECTIONS FOR GAS, STEAM, OR WATER.

Ref. No.	Inside diameter, in inches ..	⅛	¼	⅜	½	¾	1	1¼	1½	1¾	2	2¼	2½	2¾	3	3½	4
		s. d.	s. d.	s. d.	s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s d	£ s. d.	£ s. d	£ s. d.	£ s. d.
1	Tubes, from 2 to 14 ft. Per ft.	0 2	0 2½	0 3	0 4¼	0 0 6	0 0 8	0 0 11	0 1 2	0 1 6	0 1 9	0 2 6	0 3 3	0 4 0	0 4 6	0 5 6	0 7 0
	,, 12 to 23½ in. each	0 4	0 5	0 7	0 9	0 1 0	0 1 4	0 1 8	0 2 0	0 2 6	0 3 0	0 4 6	0 6 3	0 7 6	0 9 0	0 11 6	0 14 6
	,, 3 to 11½ ,, ,,	0 2	0 3	0 4	0 6	0 0 8	0 0 11	0 1 1	0 1 4	0 2 0	0 2 3	0 4 0	0 4 9	0 6 0	0 7 0	0 8 0	0 9 0
	Connecting tube, 12 to 23½ in. ,,	0 5	0 7	0 9	0 11	0 1 2	0 1 6	0 2 0	0 2 6	0 3 3	0 4 0	0 5 6	0 7 0	0 8 6	0 10 0	0 12 6	0 15 6
	,, ,, 3 to 11½ ,, ,,	0 4	0 5	0 6	0 8	0 0 10	0 1 0	0 1 3	0 2 0	0 2 6	0 3 0	0 4 6	0 5 6	0 6 6	0 7 6	0 8 6	0 10 0
	Tubular bends and lamp bends ,,	0 5½	0 6½	0 7	0 8	0 0 11	0 1 3	0 1 9	0 2 3	0 3 3	0 4 3	0 6 6	0 10 0	0 12 0	0 16 0	1 5 0	1 12 6
2	Springs, various elevations ,,	0 4	0 5	0 6	0 7	0 0 9	0 0 11	0 1 4	0 1 8	0 2 6	0 3 3	0 5 6	0 7 6	0 10 0	0 12 0	0 19 0	1 6 0
	Socket or pipe unions, wt. iron ,,	..	2 0	2 6	3 0	0 4 0	0 5 6	0 6 9	0 8 0	0 9 0	0 10 0	0 12 0	0 14 0	0 16 0	0 18 0	1 2 0	1 8 0
	Elbows, equal or diminished ,,	0 6	0 6½	0 7	0 8	0 0 10	0 1 2	0 1 9	0 2 3	0 3 0	0 3 6	0 5 6	0 8 6	0 11 0	0 14 0	1 2 0	1 8 0
5	Tees ,, ,, ,,	0 6	0 6½	0 7	0 9	0 1 0	0 1 3	0 1 9	0 2 6	0 3 0	0 3 9	0 6 0	0 9 6	0 12 6	0 16 6	1 4 0	1 10 0
6	Crosses ,, ,, ,,	0 10	1 0	1 0	1 5	0 1 9	0 2 3	0 3 0	0 3 6	0 4 6	0 5 3	0 10 6	0 16 0	1 1 0	1 10 0	2 2 0	2 10 0
14	Sockets, plain .. .. ,,	0 1½	0 1½	0 2	0 3	0 0 3½	0 0 4	0 0 6	0 0 7	0 0 9	0 1 0	0 1 6	0 2 6	0 3 0	0 3 6	0 5 0	0 6 0
15	,, diminished .. ,,	..	0 3	0 4	0 5	0 0 6	0 0 7	0 0 9	0 0 11	0 1 1	0 1 3	0 2 0	0 3 0	0 4 0	0 5 0	0 7 0	0 9 0
10, 16	Flanges .. .. .. ,,	0 8	0 9	0 10	1 0	0 1 2	0 1 4	0 1 6	0 1 9	0 2 0	0 2 6	0 3 9	0 5 0	0 6 9	0 8 6	0 10 0	0 11 6
11, 7	Caps and plugs .. .. ,,	0 2	0 3	0 3	0 4	0 0 5	0 0 6	0 0 8	0 0 10	0 1 0	0 1 3	0 2 0	0 2 6	0 3 6	0 4 9	0 7 0	0 10 0
12, 4	Backnuts and nipples .. ,,	0 1	0 2	0 2	0 3	0 0 3½	0 0 4	0 0 6	0 0 8	0 0 10	0 1 0	0 1 9	0 2 3	0 3 0	0 3 6	0 4 6	0 5 6
	Union bends, or elbows .. ,,	..	2 6	3 0	3 9	0 5 0	0 6 3	0 8 6	0 10 0	0 11 6	0 13 6	0 16 0	0 19 0	1 2 0	1 5 0	1 10 0	1 16 0
3	Elbows, round backed, wt. iron ,,	0 7	0 7	0 8	0 9	0 1 0	0 1 4	0 1 11	0 2 6	0 3 4	0 3 10	0 6 6	0 10 0	0 13 0	0 16 0	1 5 0	1 12 0
13	Iron main cocks .. .. ,,	2 3	2 3	2 9	3 6	0 4 6	0 6 6	0 8 6	0 11 0	0 14 0	0 18 0	1 7 0	1 16 0	2 4 0	2 10 0	3 15 0	4 10 0
	,, ,, Brass plugs .. ,,	...	..	4 6	5 6	0 7 6	0 10 6	0 15 0	0 19 6	1 5 0	1 12 0	2 7 0	3 0 0	4 10 0	5 10 0	7 0 0	9 10 0
	,, ,, Roundway .. ,,	..	..	3 6	4 0	0 5 6	0 7 6	0 10 0	0 13 0	0 17 6	1 2 0	1 18 0	2 14 0	3 2 0	3 10 0	5 0 0	8 0 0
	,, ,, ,, Brass plugs ,,	..	..	5 0	6 6	0 9 0	0 13 0	0 19 0	1 8 0	1 16 0	2 2 0	3 0 0	4 5 0	5 5 0	6 0 0	9 0 0	14 0 0
	Spanners for cocks, wrt. iron ,,	..	..	1 0	1 4	0 1 8	0 2 0	0 2 4	0 3 0	0 3 6	0 4 0	0 4 9	0 6 0	0 7 6	0 9 0	0 12 0	0 14 0
	,, ,, Mlble. cast iron .. .. .. ,,	..	..	0 7	0 8	0 0 10	0 1 2	0 1 8	0 2 2	0 2 9	0 3 3	0 4 9	0 6 0	0 7 6	0 9 0	0 12 0	0 14 0
	Syphon boxes, 1 quart .. ,,	..	..	..	11 0	0 12 0	0 13 0	0 14 0	0 15 0	0 15 6	0 16 0	0 18 0	..	..	..	..	..
	,, ,, 2 ,, .. ,,	..	..	..	..	0 16 0	0 17 0	0 18 0	0 19 0	1 1 0	1 3 0	1 5 0	1 10 0	1 15 0	2 0 0	..	..
	,, ,, 3 ,, .. ,,	..	..	..	..	1 0 0	1 2 0	1 4 0	1 5 0	1 6 6	1 8 0	1 12 0	1 15 0	2 0 0	2 5 0	2 10 0	2 16 0
	,, ,, 4 ,, .. ,,	..	..	..	..	1 1 0	1 3 0	1 5 0	1 7 0	1 9 0	1 11 0	1 14 0	1 18 0	2 2 0	2 7 0	2 14 0	3 0 0
8	Malleable cast round elbow ,,	0 6	0 6½	0 7	0 8	0 0 10	0 1 2	0 1 9	0 2 3	0 3 0	0 3 6	0 5 6	0 9 0	0 12 0	0 15 0	1 10 0	2 0 0

Tubes of intermediate diameters are charged at the same price as the next larger size. Angle tees, crosses, and pieces with a variety of outlets are made to order.

It is customary to charge packages for these goods at half price, and no allowance is made if they are returned.

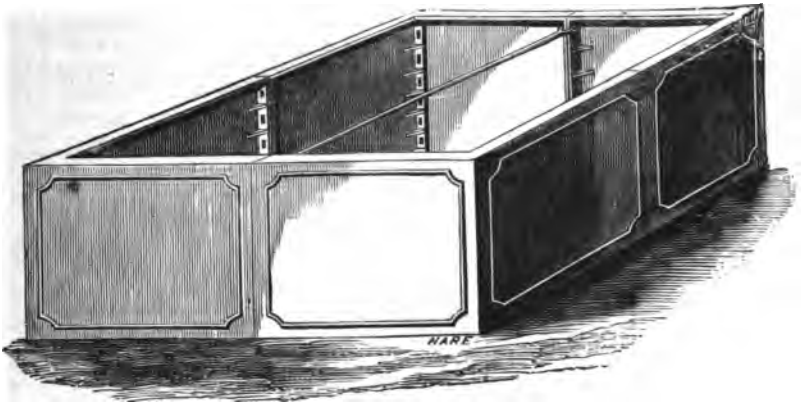


Fig. 465.

CAST-IRON TANKS, Fig. 465, are usually made in plates about 4 feet square, with internal flanges, and ⅝ in. thick, but they can be made larger, smaller, or thicker, as may be required, with internal or external flanges, and with round or square corners. The subjoined quotations are based on the present value of metals, the tanks are fitted together, and the necessary tank bolts and wrought-iron stays are substituted as well as iron cement for caulking, the plates are painted one coat of oil colour, and each plate is marked to facilitate erection at destination.

Length in feet	4	8	8	12	12	12
Breadth	4	4	8	4	8	12
Height	4	4	4	4	4	4
No. of gallons	400	800	1600	1200	2400	3600
Price complete, as described, each	£14 6 0	£23 2 0	£39 12 0	£31 17 0	£45 2 0	£52 0 0

Length in feet	4	8	8	12	12	12
Breadth	4	4	8	4	8	12
Height	8	8	8	8	8	8
No. of gallons	800	1600	3200	2400	4800	7200
Price complete, as described, each	£26 4 0	£39 12 0	£60 17 0	£48 8 0	£66 7 0	£74 16 0

CAST-IRON TANK PLATES, fitted ready for erecting, including bolts, stays, and cement.

Thickness of plates in inches	½	⅝	¾
Price per ton	£11 0 0	£10 0 0	£9 2 0

CAST-IRON TANK PLATES, with planed joints, fitted ready for erection, including bolts, stays, and packing.

Thickness of plates in inches	½	⅝	¾
Price per ton	£13 5 0	£11 10 0	£10 4 0

CAST-IRON TANK PLATES, plain castings, not fitted.

Thickness of plates in inches	½	⅝	¾
Price per ton	£9 10 0	£9 0 0	£8 0 0

The cost of planing flanges of tank plates is about £2 per ton, varying according to the weight of plates and the width of flanges.

CIRCULAR TANKS, £11 to £13 per ton, according to the size required.

WROUGHT-IRON TANKS, WITH OPEN TOPS. The sizes given in the subjoined list are usually sent rivetted together. Larger sizes are made in plates, and a sufficient supply of rivets is provided to fit together in place. Irregular sized tanks are charged extra.

Length	1 ft. 10 in.	2 ft. 0 in.	2 ft. 0 in.	2 ft. 7 in.	2 ft. 7 in.	2 ft. 8 in.	2 ft. 10 in.	3 ft. 0 in.
Breadth	1 ft. 4 in.	1 ft. 4 in.	1 ft. 6 in.	1 ft. 6 in.	1 ft. 7 in.	1 ft. 8 in.	1 ft. 10 in.	2 ft. 0 in.
Depth	1 ft. 4 in.	1 ft. 6 in.	1 ft. 8 in.	1 ft. 8 in.	2 ft. 0 in.	2 ft. 2 in.	2 ft. 2 in.	2 ft. 2 in.
No. of gallons	20	25	30	40	50	60	70	80
Price, galvanized	£0 18 6	£0 19 6	£1 0 6	£1 5 6	£1 9 9	£1 13 0	£1 17 0	£2 0 3
„ painted	0 17 0	0 18 3	0 19 3	1 3 9	1 7 6	1 10 3	1 13 9	1 16 6
„ ⅛th plate „ galvanized	..	..	..	..	2 10 0	2 17 3	3 4 0	3 9 6
„ painted	..	..	..	..	1 12 0	1 15 8	1 17 6	1 19 9

Length	3 ft. 0 in.	3 ft. 0 in.	3 ft. 3 in.	3 ft. 4 in.	3 ft. 5 in.	3 ft. 8 in.	3 ft. 9 in.	3 ft. 10 in.
Breadth	2 ft. 0 in.	2 ft. 2 in.	2 ft. 3 in.	2 ft. 4 in.	2 ft. 4 in.	2 ft. 4 in.	2 ft. 5 in.	2 ft. 6 in.
Depth	2 ft. 5 in.	2 ft. 6 in.	2 ft. 6 in.	2 ft. 6 in.	2 ft. 8 in.	2 ft. 8 in.	2 ft. 10 in.	3 ft. 0 in.
No. of gallons	90	100	110	120	130	140	150	175
Price, galvanized	£2 3 0	£2 5 9	£2 9 0	£2 12 3	£2 15 9	£2 19 0	£3 1 9	£3 10 6
„ painted	1 18 6	2 0 9	2 4 0	2 6 3	2 9 0	2 11 9	2 15 0	3 1 9
„ ⅛th plate „ galvanized	3 12 9	3 17 0	4 1 6	4 5 9	4 10 3	4 14 9	4 19 0	£5 8 0
„ painted	2 2 0	2 4 0	2 7 6	2 10 3	2 13 0	2 15 9	2 18 6	3 6 0

Length	4 ft. 0 in.	5 ft. 0 in.	5 ft. 6 in.	5 ft. 6 in.	6 ft. 0 in.	6 ft. 0 in.	6 ft. 6 in.	6 ft. 9 in.	7 ft. 0 in.
Breadth	2 ft. 9 in.	2 ft. 9 in.	3 ft. 0 in.	3 ft. 6 in.	3 ft. 6 in.	3 ft. 6 in.	3 ft. 8 in.	3 ft. 10 in.	4 ft. 0 in.
Depth	3 ft. 0 in.	3 ft. 0 in.	3 ft. 0 in.	3 ft. 0 in.	3 ft. 2 in.	3 ft. 6 in.	3 ft. 6 in.	3 ft. 6 in.	3 ft. 6 in.
No. of gallons	200	250	300	350	400	450	500	550	600
Price, galvanized	£3 17 6	£4 17 6	£5 16 9	..	..	..	..	..	..
„ painted..	3 8 3	3 19 3	4 8 0	..	..	..	..	..	..
„ ⅛th plate „ galvanized	5 17 9	6 12 0	7 3 0	£7 14 0	£8 10 6	£9 1 6	£9 12 6	£10 3 6	£10 14 6
„ painted..	3 12 9	4 4 9	4 13 6	5 2 3	5 10 0	5 17 9	6 6 6	6 14 9	7 3 0

Covers for tanks ½*d.* to 1*d.* per gallon extra.

WROUGHT-IRON TANK BOLTS, with square necks and square nuts, and washers.

Size in inches	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{5}{8}$	× 2 in. to 3 in. long
Price per gross ..	£0 18 0	£1 0 0	£1 2 0	£1 4 0	

WROUGHT-IRON GALVANIZED HOT WATER TANKS, with manhole and covers bolted down.

Length	1 ft. 10 in.	2 ft. 0 in.	2 ft. 0 in.	2 ft. 7 in.	2 ft. 7 in.
Breadth	1 ft. 4 in.	1 ft. 4 in.	1 ft. 6 in.	1 ft. 6 in.	1 ft. 7 in.
Depth	1 ft. 4 in.	1 ft. 6 in.	1 ft. 8 in.	1 ft. 8 in.	2 ft. 0 in.
No. of gallons	20	25	30	40	50
Price, made of plates ordinary strength	£1 11 0	£1 14 6	£1 18 0	£2 4 0	£2 10 0
Price if $\frac{1}{8}$th plate	1 18 6	2 2 6	2 6 3	2 14 0	2 19 6

Length	2 ft. 8 in.	2 ft. 10 in.	3 ft. 0 in.	3 ft. 0 in.	3 ft. 0 in.
Breadth	1 ft. 8 in.	1 ft. 10 in.	2 ft. 0 in.	2 ft. 0 in.	2 ft. 2 in.
Depth	2 ft. 2 in.	2 ft. 2 in.	2 ft. 2 in.	2 ft. 5 in.	2 ft. 6 in.
No. of gallons	60	70	80	90	100
Price, made of plates ordinary strength	£2 15 0	£3 0 6	£3 8 3	£3 17 0	£4 3 9
Price if $\frac{1}{8}$th plate	3 12 6	3 19 9	4 3 9	4 10 9	4 18 0

WROUGHT-IRON GALVANIZED CIRCULAR TANKS, with angle iron rings round open top.

Diameter	23 in.	28½ in.	30 in.	33 in.	36 in.
Height	36 in.	36 in.	40 in.	52 in.	55 in.
No. of gallons	50	75	100	150	200
Price	£1 17 3	£2 2 9	£2 8 3	£3 0 6	£3 19 9

WROUGHT-IRON CIRCULAR TANKS, made for export, to nest inside each other for convenience of stowage, with stays and loose covers. The dimensions given are those adopted by the Author's firm, but they may be varied to any extent desired.

Diameter	3 ft. 0 in.	3 ft. 6 in.	4 ft. 0 in.	4 ft. 6 in.	5 ft. 0 in.
Height	2 ft. 3 in.	3 ft. 6 in.	4 ft. 0 in.	5 ft. 3 in.	6 ft. 3 in.
No. of gallons	100	200	300	500	750
Price, painted	£6 0 0	£10 10 0	£12 15 0	£21 0 0	£27 0 0

Diameter	5 ft. 6 in.	6 ft. 6 in.	7 ft. 0 in.	8 ft. 6 in.
Height..	7 ft. 0 in.	8 ft. 0 in.	8 ft. 6 in.	8 ft. 6 in.
No. of gallons	1000	1500	2000	3000
Price, painted..	£30 0 0	£40 15 0	£45 15 0	£60 10 0

Gun-metal draw-off cocks and iron overflow pipes, from £2 3*s.* to £2 18*s.* 6*d.* each tank. Square or oblong tanks of the same thickness and contents, average about 20 per cent. more than the round tanks.

WROUGHT-IRON TANK PLATES.—For convenience of shipment and transport, tanks similar in appearance to Fig. 465 are made entirely in wrought iron. They are worth about £20 per ton, but in many cases the reduction in weight of parts, and the freedom from risk of breakage, far outweighs the disadvantage of the extra cost.

FILTRATION.

Much attention has been given during the last few years to this very important question, and it is now generally admitted that the health and often the lives of large masses of people depend very greatly upon the purity of the supply of drinking water. It would be beyond the province of a work of this character to enter minutely into the subject of filtration for ordinary domestic purposes, but when the storage of large quantities of water and pumping machinery is under consideration, many occasions must arise, particularly in foreign countries and in the colonies, where information on this subject is not readily accessible. In such cases the subjoined remarks, illustrated by engravings selected from well-known systems of filtration, will probably be useful.

SPONGY IRON TANK FILTER, Figs. 466 to 469, show a system of pumping water by filtration, through spongy iron or metallic iron reduced from an oxide without fusion, and therefore in a loose spongy state. Access is readily obtained to all parts of the filter for cleaning or renewing the filtering materials.

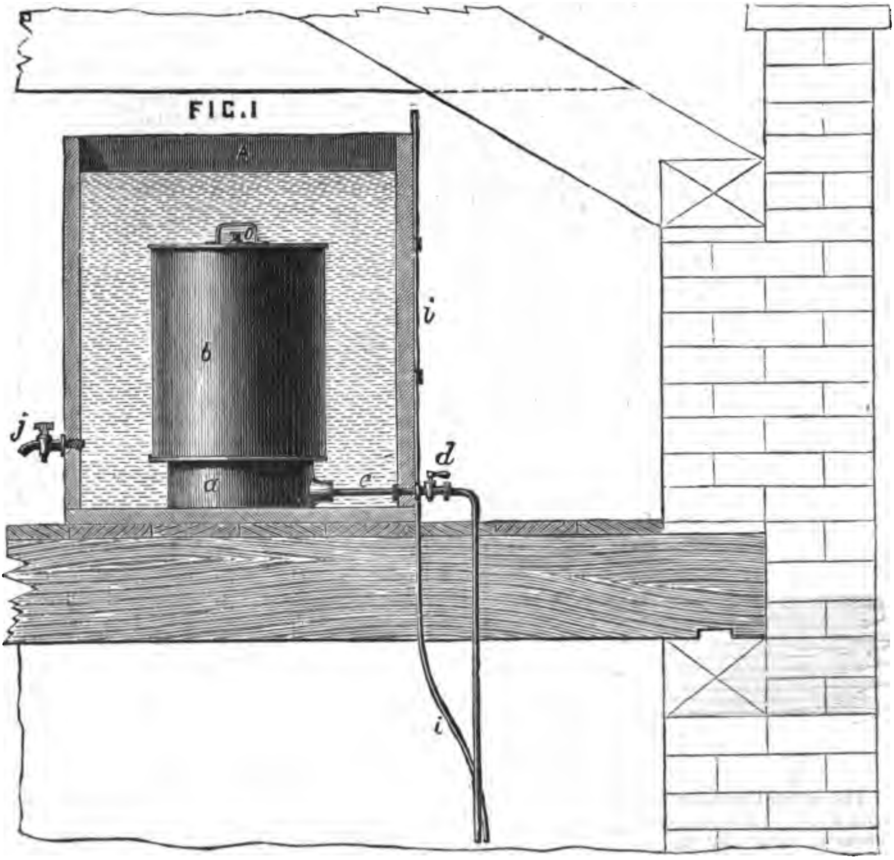


Fig. 466.

Fig. 466 is a sectional view of a tank with the filter (*a*) in position, fitted with syphon cover (*b*), pipe from filter to regulator (*c*), stop cock (*d*), air tube (*i*), tap for unfiltered water (*j*), air vent to cover (*o*). Two feet of water (when the cistern is full) is sufficient for all sizes of filters. The space from top of cistern to ceiling should be not less than 22 inches.

Fig. 468 is a sectional view of the filter, and shows clearly its construction and working.

Fig. 467 illustrates the reservoir for filtered water (*h*), regulator enclosed in glass vessel (*g*), stop cock (*e* and *f*), pipe to waste for washing filter (*k*), pipe for conveying filtered water as required (*l*), reservoir stand (*m*), and filtered water tap (*n*).

To wash the filter on starting, or when renewing the materials, close the stop-cocks *e* and *f'* and open *d* and *f*, so that the water does not pass through the regulator. The pipe *l* must be in connection with a branch pipe leading to the delivery tap. When commencing to use the filter, or in case of stoppage owing to an insufficient supply of water in the cistern, the filter must be covered with water, and the air vent (*o*) unscrewed and the cover (*b*) pressed down until air ceases to escape. The cap (*o*) must be securely replaced. For filtering water, shut off stop-cock (*f*) and open the cocks *d*, *e* and *f'*; the tap (*j*) for supplying unfiltered water is so placed as to give warning when the water in cover (*b*) is low. When this occurs the cock (*d*) should be closed.

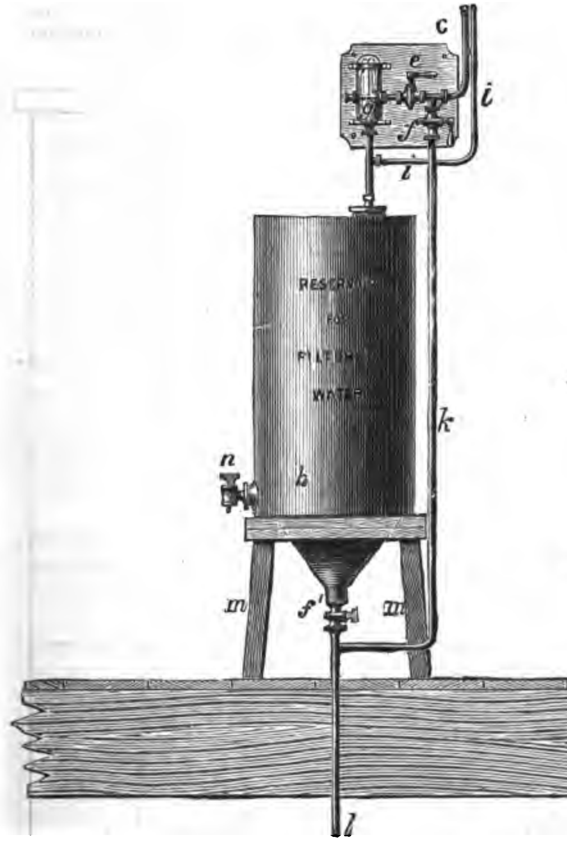


Fig. 467.

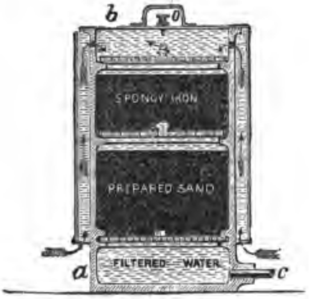


Fig. 468.

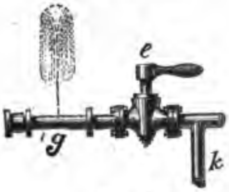


Fig. 469.

The vertical distance from the regulator to the mean level of water in the cistern should be about 6 feet, or the regulators must be specially prepared for a different level. It is necessary to bear in mind that the slower the speed of filtration the greater is the degree of purification obtained. The filtered water can readily be iced. Fig. 469 is an enlarged view of the regulator (*g*).

PRICES OF FILTERS (Figs. 466 to 469), including filter, complete with charges, cover to filter, regulator arrangement, stop-cocks (excepting *j*), and a stone-water reservoir (contents 12 gallons) with stand. (See page 160.)

When necessary the tubing is provided, and experienced workmen are sent out to fix and start these filters, the cost of this work being in all cases an additional charge.

Regulated to yield in 24 hours	25 gallons each	£8 8 0
" " "	50 "	10 0 0
" " "	75 "	11 10 0

Fig. 470 is a form of filter where the iron dissolved by the passage of water through spongy iron is not required to be separated, or where it is intended to be removed by subsidence in a second tank. A represents the space above the unfiltered water; B the unfiltered water; C the bed of spongy iron; H the supply pipe; I the ball-cock; K the outlet for filtered water, and L the perforated false bottom.

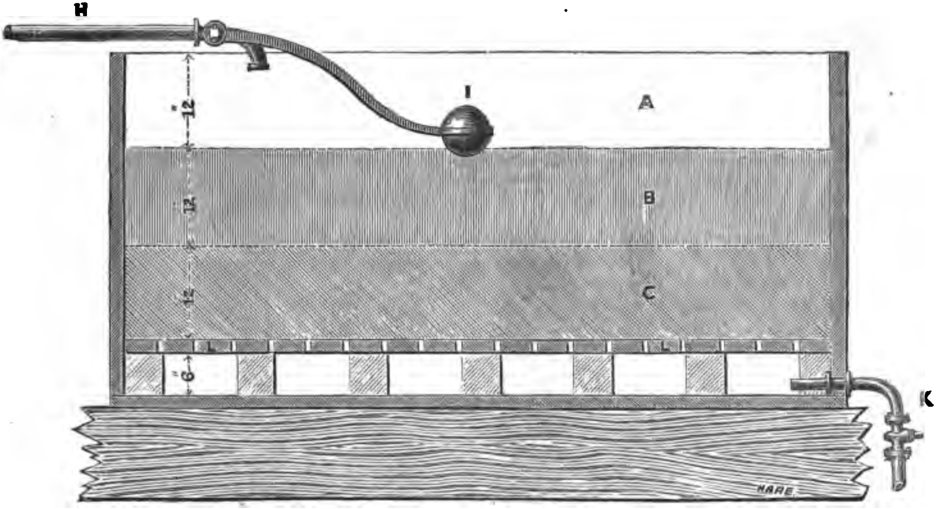


Fig. 470.

Another kind of filter, similar in construction to Fig. 470, is made in which the water passes out free from iron. These are provided with three layers of prepared sand immediately under the bed of spongy iron (*c*). The cost of this system of filtration varies according to the size of tank and the number of gallons required to be filtered.

Ten tons of spongy metallic iron are sufficient to purify in 24 hours 40,000 gallons of ordinary Thames water for drinking purposes, or at the rate of 1660 gallons per hour, equal in bulk to about 200 cubic feet. The filters may be constructed of brickwork, wood, or other suitable material. The layer of spongy iron should be 9 to 12 inches thick.

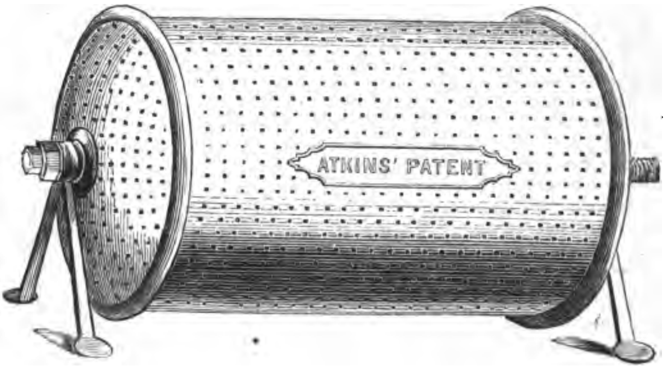


Fig. 471.

ATKINS' TANK FILTER, Fig. 471. In this system of filtration an earthenware or galvanized iron hollow cylinder is used, the ends being moveable to facilitate cleansing. The cylinder is fitted with blocks of pure charcoal, surrounded by loose charcoal to effect a rough filtration first; the water passes through this to the central pipe, and water can be drawn at any time. These filters are supported on legs to keep them out of the sediment, which naturally falls to the bottom of the cistern; all the fittings are of galvanized iron. The water enters the filter at all parts of its surface, and undergoes two filtrations: firstly, through loose charcoal; and secondly, through the carbon blocks placed in the centre of the filter; and it is drawn from a perforated pipe passing through the centre of the carbon block; therefore the process is a combination of upward, downward, and lateral filtration. This filter is made with a flat bottom for shallow cisterns without extra cost.

For the supply of single drinking taps, all that is necessary is to place the filter of a size according to that of the tap to be supplied on the bottom of the cistern, and connect it by means of a short piece of pipe to the tap from whence the water has to be drawn, or to the pipe which supplies the tap, as the case may be. An ordinary plumber can do this.

PRICES OF SINGLE CISTERN FILTERS, Fig. 471, adapted to supply single drinking taps.

No. 1	Small size, to supply one ⅜" draw off tap .. .. Length, including union, &c., 24" by 11" diameter.	£3 0 0
„ 2	Small size, to supply one ½" draw-off tap .. .. Length, including union, &c., 30" by 11" diameter.	4 0 0
„ 3	Medium size, to supply one ⅝" draw-off tap .. .. Length, including union, &c., 36" by 14" diameter.	5 5 0
„ 4	Second medium size, to supply one ¾" tap or ½" tap and boiler .. Length, including union, &c., 36" by 16" diameter.	7 10 0
„ 5	Large size, to supply one 1" tap or ¾" tap and boiler .. .. Length, including union, &c., 45" by 18" diameter.	9 10 0

COMPOUND SYSTEM OF FILTRATION.—This is a new arrangement of plate filtration in combination with the cistern filter, Fig. 471, and has been used for treating the whole water supply for large establishments in this country and abroad. It is stated that by this process the most impure water may be converted into a pure and wholesome supply, also that the choking of boilers is prevented, and there is comparative safety from the danger of infection through the medium of sewage contamination in water. The advantages of this system are:—

1.—The water undergoes five distinct and independent filtrations, each separate process being graduated in accordance with the special characteristics of the water to be purified.

2.—The arrangement can be constructed on any scale and adapted for the supply of the largest establishments.

3.—All the parts can be cleaned without disturbing the supply, and every separate part can be instantly removed, and duplicate parts substituted where removals are required. The whole apparatus can thus be kept in thorough working order by an unskilled workman, and at a small outlay for fresh materials only.

Fig. 472 gives plan and sectional elevation of the compound filter. It is divided into two parts: firstly, a cistern containing the preliminary filtering apparatus; and secondly, a cistern containing a set of carbon cistern filters. The process is as follows: the water enters the first cistern by a ball cock at A, and passes through porous charcoal plates in the frame, B placed upright across the tank. It then passes through a body of loose charcoal C; next through another set of plates D with fine granulation, and then by the cock E into the second or larger cistern containing the cistern filters. So soon as a tap is turned on below, water passes through the cistern filters F F into the general supply pipe of the house, thus undergoing two more filtrations at the last moment. The waste pipes are shown at W. The plates can be cleaned without removal, and duplicate parts can always be obtained

In order to carry out a complete system of sanitary water supply, it is advisable that the apparatus should be placed in an elevated position, so as to command the whole of the establishment. It is then securely connected to the main supply pipe, and the whole of the water entering the house must undergo thorough and proper filtration.

Although it may be fairly urged that in most large cities the water supplied is fairly pure, it is not always suitable for drinking or culinary purposes; and it cannot be denied that, although pecuniary outlay has not been spared in the construction of wells, pumping-machinery, &c., many mansions, and even whole districts, are sadly in want of that most necessary of all things, *pure water*. In many cases, such as when the water is charged with iron or lime, the cost of having a filter fitted on the main supply will more than recoup itself in the increased durability of the piping and boilers about the establishment.

The cost of this system of filtration is governed by the quantity of water it is required to filter in a given time, and there are so many conditions to fulfil, that it is impossible to give any general information as to cost.

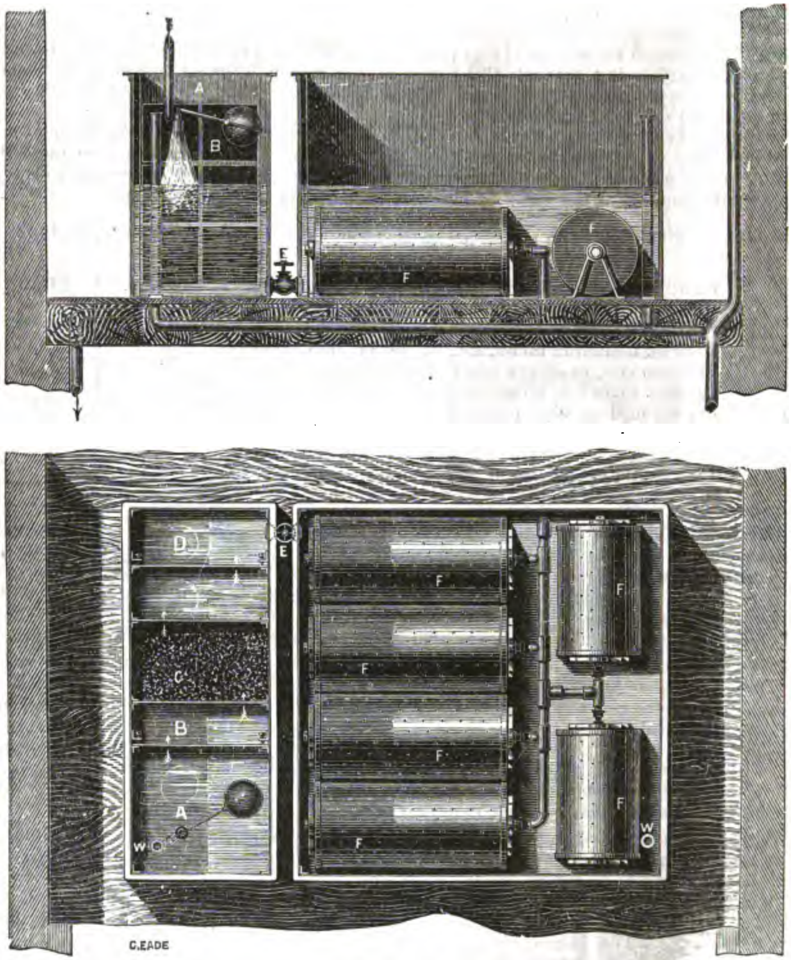


Fig. 472.

WATER SUPPLY. Fig. 473 is a sectional view of a water tower with well beneath, showing the arrangement of pumps, filters, &c., and consists of a water tower of sufficient height to command the whole of the premises, including the outbuildings; a set of pumps fixed in the well, worked by a horse or pony; a large storage tank at the top of the water tower, containing a reserve of water—this should be large enough to be of service in case of fire; and a compound filtering apparatus as before described, placed in a separate chamber, where access can always be had to it for cleaning, &c.

Galvanized iron pipes carry the water from the filtering apparatus to the main pipe supplying the house, and to large cocks placed in the yard or elsewhere. In this arrangement, though the pipes and cocks may be of large size, a continuous supply of filtered water can be maintained.

A water tower thus constructed may be made to serve other purposes than that of holding the tanks. The ground floor and first floor can be available for storage purposes, the two upper stories only being occupied by the tanks and filters.

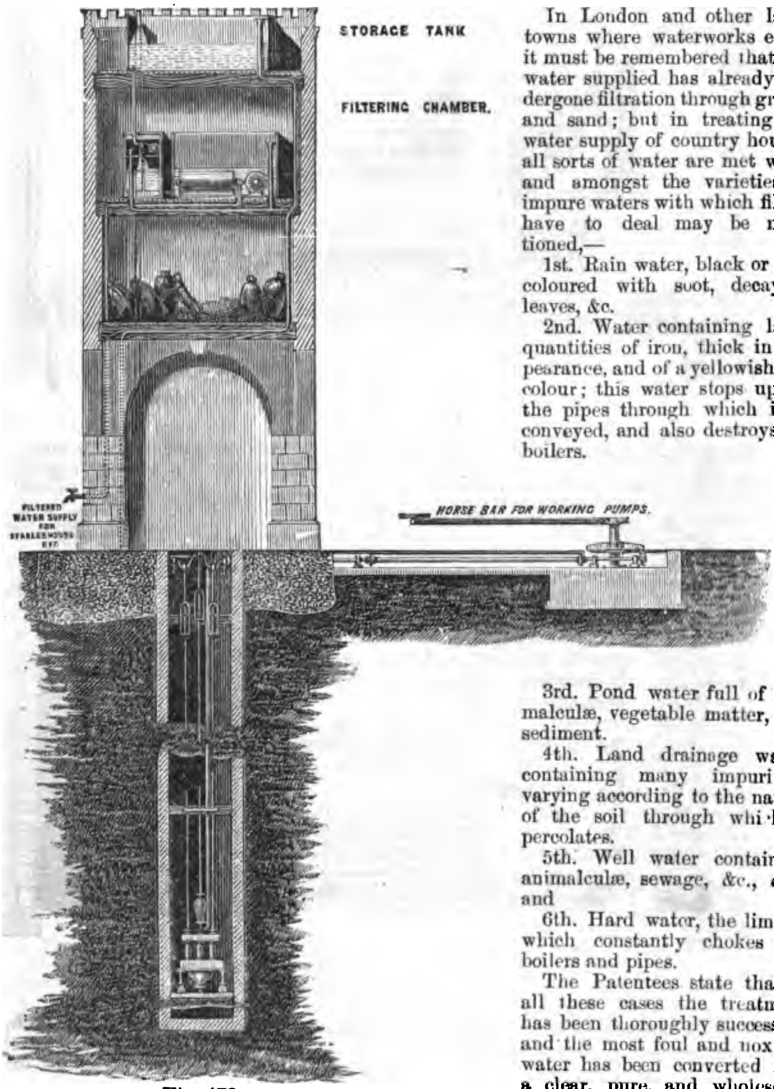

STORAGE TANK
FILTERING CHAMBER.
FILTERED WATER SUPPLY FOR STABLES HOUSE ETC.
HORSE BAR FOR WORKING PUMPS.

Fig. 473.

In London and other large towns where waterworks exist, it must be remembered that the water supplied has already undergone filtration through gravel and sand; but in treating the water supply of country houses, all sorts of water are met with, and amongst the varieties of impure waters with which filters have to deal may be mentioned,—

1st. Rain water, black or discoloured with soot, decaying leaves, &c.

2nd. Water containing large quantities of iron, thick in appearance, and of a yellowish-red colour; this water stops up all the pipes through which it is conveyed, and also destroys the boilers.

3rd. Pond water full of animalculæ, vegetable matter, and sediment.

4th. Land drainage water, containing many impurities, varying according to the nature of the soil through which it percolates.

5th. Well water containing animalculæ, sewage, &c., &c.; and

6th. Hard water, the lime in which constantly chokes the boilers and pipes.

The Patentees state that in all these cases the treatment has been thoroughly successful, and the most foul and noxious water has been converted into a clear, pure, and wholesome supply.

A general arrangement of this kind is easily modified to suit local conditions. In some cases steam power may be profitably used instead of horse power, the lower part of the water tower forming the engine and boiler house, the room above being used for light machinery such as corn crushers, flour mills, chaff cutter, &c., driven by the same engine as is used for pumping.

USEFUL TABLES AND MEMORANDA RELATING TO PUMPING MACHINERY.

Table of Power required to raise Water from Deep Wells.

Gallons of water raised per hour	200	350	500	650	800	1000
Height of lift for one man working on crank, in feet ..	90	51	36	28	22	18
„ one donkey working on gin „ ..	180	102	72	56	45	36
„ one horse working on gin „ ..	630	357	252	196	154	126
„ one horse-power steam engine „ ..	990	561	396	308	242	198

This table is based on the assumption that a good class of well pump will be used of the treble or double barrel type, of lift pumps with valves in the buckets, and an additional retaining valve for lifts above 100 feet.

Useful Numbers for Single-Acting Pumps.

D = Diameter of pump in inches.
S = Stroke of plunger, or piston, in inches.

$D^2 \times S \times .7854$ = cubic inches per stroke.
$D^2 \times S \times .002833$ = gallons per stroke.
$D^2 \times S \times .0004545$ = cubic feet per stroke.
$D^2 \times S \times .02833$ = lbs. of fresh water per stroke.

Useful Memoranda relating to Waterworks.

The consumption of water in non-manufacturing towns may be estimated at 16 gallons per head, but in towns where there are many factories at least 20 gallons per head should be allowed; the mains should be at least large enough for double the average supply, and in designing waterworks the probable increase of population and the levels of ground in the immediate neighbourhood of the town should be carefully considered and provided for.

In England impounding reservoirs should be large enough to contain from 120 to 200 days' supply, according to the average rainfall in the district to be supplied.

Service reservoirs should contain at least three days' supply.

About 60 per cent. of the total rainfall is estimated to be available for storage in England, but a loss of about 10 per cent. of this should be allowed for overflow of storm water.

A series of observations made by Mr. Dickinson, and extending over eight years, show that the average infiltration in England was 42.4 per cent. of the whole rainfall, and that the amount varies greatly according to the season.

	Mean fall. inches.	Mean infiltration. inches.	Per centage.
November, December and January ..	7.325	6.370	86.9
February, March and April	5.044	2.930	58.0
May, June and July	6.356	0.189	2.9
August, September and October	7.889	1.805	22.8
Totals	26.614	11.294	42.4

The eight years referred to in the above tables appear to have been rather below the average English rainfall, which is generally estimated at about 42 inches: much, however, depends upon the district. Mr. Dickenson's observations were made in the neighbourhood of Watford, where the soil is sandy gravelly loam overlying chalk.

Mr. Prestwick estimates the amount of infiltration in three of the principal water bearing strata surrounding the metropolis, as follows:—

	Mean annual rainfall.	Mean infiltration.	Per centage.
Lower tertiary sand	25 inches.	12	48
Upper green sand	28 „	10	36
Lower green sand	26½ „	16	60

Mr. Stephenson estimated the mean infiltration round Watford at 44.8 per cent.

The mean daily evaporation in England is .08 inch, or over 50 per cent. of the rainfall, but evaporation varies according to the district, being considerably greater on undulating rocky districts than on flat countries.

FORMULA TO FIND HORSE POWER OF PUMPING ENGINES.

G = the number of gallons required per hour.
C = the number of cube feet required per hour.
F = the height in feet to which the water is to be raised.
= horse power.

$$\text{Then} \quad = \frac{G \times F}{198000} \text{ or } = \frac{C \times F}{31750.}$$

About 70 or 80 per cent. must be added to the number obtained by above formula to allow for friction leakage and other contingencies; the result obtained by the formula is not in nominal but actual horse power (33,000 ft.-lbs.)

FILTERS FOR WATERWORKS.

1 square yard of filter bed should be provided for each 700 gallons required in 24 hours, and the filter bed should be 6 feet in total depth, composed as follows:—

2 feet 6 inches of fine sand.
6 inches of course or common sand.
6 inches of shells.
2 feet 6 inches of gravel.

Perforated pipes or culverts built of perforated or very porous bricks should traverse the bottom of filter beds to collect the filtered water; air pipes should be provided on these culverts to allow air to escape. The fine sand forming the top stratum of filter beds should be frequently washed, and to enable this to be done without interfering with constant supply, a spare bed should be provided.

USEFUL MEMORANDA RELATING TO WATER.

WEIGHT, VOLUME, &C., OF WATER AT THE FOUR PRINCIPAL TEMPERATURES.

	Temperature.		Weight.			Volume of 1lb. of water.	
	Fahrenheit.	Centigrade.	Cubic ft. lbs.	Cubic in. lbs.	Cubic in. ozs.	Cubic feet.	Cubic inches.
Freezing point under 1 atmosphere ..	32°	0°	62·418	·03612	0·5779	·016021	27·684
Point of maximum density	39·1°	4°	62·425	·036125	0·5780	·016019	27.680
Point of British standard of weight ..	62°	16·66°	62·355	·03608	0·5773	·016037	27·712
Boiling point under 1 atmosphere ..	212°	100°	59·640	·03451	0·5522	·016770	28 978

It may be here remarked that the standard used in France for comparing the specific gravity of solids is pure water at its maximum density, or 4° centigrade; this should not be overlooked when using French tables of specific gravities.

Sea water contains on an average about 3·44 per cent. of solid matter, but it varies considerably, the water of the Red Sea containing 4·3 per cent. and that of the Baltic 5 per cent. A cubic foot of average sea water at the standard temperature weighs 64 lbs., and its specific gravity as compared with fresh water is 1·026.

1 gallon of water at the standard temperature (62° Fah.) weighs approximately 10 lbs.
35·9 cubic feet or 224 gallons " " " 1 ton.
1·795 cubic feet " " " 1 cwt.
·449 cubic feet " " " 1 qr.
1 cubic yard " " " 15 cwt.
1 cubic metre " " " 1 ton.

A pipe one yard long holds about as many lbs. of water as the square of its diameter in inches.

A pressure of 1 lb. per square inch is equivalent to a head of water of 2·3093 feet.
" " " " " " 27·71 inches.
" 14 7 lbs. or 1 atmosphere " " " 33·947 feet.
" " " " " " 10·347 metres.
" 0·433 lbs. " " " " 1 foot.
" 43·3 lbs. " " " " 100 feet.

For the theoretical velocities due to various heads and memoranda relating to rainfall, &c., see tables at the end of Section 1.

FORMULA TO ASCERTAIN THE TIME REQUIRED TO FILL AND EMPTY TANKS, &C.

Time employed in filling and emptying tanks or cisterns when the supply and consumption are going on simultaneously.

G = gallons of water running into tank per minute.
g = „ running out „
C = contents of cistern in gallons.
F = minutes required for filling tank.
E = „ „ emptying tank.

$$F = \frac{C}{G - g} \qquad E = \frac{C}{g - G}$$

Time employed in emptying tanks with vertical sides, the water flowing from a hole in the bottom.

A = area of surface of water in square inches.
a = area of orifice in square inches.
D = depth of tank in feet.
E = minutes required for tank to empty itself.

$$E = \frac{A\sqrt{D}}{222\ a}$$

JETS OF WATER UNDER PRESSURE.

Ratio of compression in air vessel	$\frac{1}{2}$	$\frac{1}{3}$	$\frac{1}{4}$	$\frac{1}{5}$	$\frac{1}{6}$	$\frac{1}{7}$	$\frac{1}{8}$	$\frac{1}{9}$	$\frac{1}{10}$
Height of jet of water in feet	33	66	99	132	165	198	231	264	297
Pressure in lbs. per square inch	30	45	60	75	90	105	120	135	150
Equivalent head of water in feet	69	104	138	173	208	242	277	311	346

The heights refer to fire-engine jets or jets of a similar character.

The loss due to friction naturally varies according to the length of piping and the form and diameter of the nozzle employed, the number of bends in the piping; irregularities in the internal surfaces of the pipe also affect the friction.

FLOW OF WATER IN SEWERS.

X = area of sewer in square feet divided by wetted perimeter in feet.
F = fall of sewer in feet per mile.
V = velocity at which sewage flows in feet per minute.
A = area in square feet of cross section of sewage.
C = cubic feet of water delivered per minute.

$$V = 55\sqrt{X \times 2\ F} \qquad C = V \times A$$

CENTRIFUGAL PUMPS.

S = the speed of the periphery of disc or fan in feet per second.

H = the height in feet to which water is to be raised including allowance of 20 per cent. for friction.

$$S = 1 \cdot 25\sqrt{64 \cdot 3 \times H}$$

Although the efficiency of a well designed centrifugal pump working against a low lift (up to 20 feet) may be as high as 75 or 76 per cent., it is not safe to estimate their average efficiency above 50 per cent., the form of blade (curving backwards) introduced by Mr. Appold gives decidedly the most economical results, having been proved by experiment to be superior to straight radial arms, straight arms placed at an angle or to the double curved form advocated by the late Professor Rankine.

FRICTION OF WATER IN PIPES.—The tables given on the two following pages are calculated from Weisbach's formula (given at the end of Section 1) for pipes 100 feet in length, and give:—

(1) the velocity of the water in feet per second.
(2) the internal diameter of the pipe.
(3) the head in feet required to overcome the friction; and
(4) the number of cubic feet delivered per minute. So that when any two of these four quantities are given the others can be found.

FRICTION OF WATER IN PIPES.

Velocity of water, in feet per second.	Head to produce this velocity, in feet.	Internal diameter of pipe, in inches.																					
		3		3½		4		4½		5		6		7		8		9		10		11	
		Head to overcome friction, in feet.	Cubic feet per minute.	Head to overcome friction, in feet.	Cubic feet per minute.	Head to overcome friction, in feet.	Cubic feet per minute.	Head to overcome friction, in feet.	Cubic feet per minute.	Head to overcome friction, in feet.	Cubic feet per minute.	Head to overcome friction, in feet.	Cubic feet per minute.	Head to overcome friction, in feet.	Cubic feet per minute.	Head to overcome friction, in feet.	Cubic feet per minute.	Head to overcome friction, in feet.	Cubic feet per minute.	Head to overcome friction, in feet.	Cubic feet per minute.	Head to overcome friction, in feet.	Cubic feet per minute.
2.0	.062	.659	5.89	.565	8.02	.494	10.4	.439	13.2	.395	16.3	.329	23.5	.282	32.0	.247	41.9	.220	53.0	.198	65.4	.180	72.2
2.2	.075	.780	6.48	.669	8.82	.585	11.5	.520	14.6	.468	18.0	.390	25.9	.334	35.3	.293	46.1	.260	58.3	.234	72.0	.218	87.1
2.4	.090	.911	7.07	.781	9.62	.683	12.5	.607	15.9	.547	19.6	.456	28.2	.390	38.5	.342	50.2	.304	63.6	.273	78.5	.248	95.0
2.6	.105	1.05	7.65	.901	10.4	.788	13.6	.701	17.2	.631	21,3	.526	30.6	.450	41.7	.394	54.4	.350	68.9	.315	85.1	.287	103
2.8	.122	1.20	8.24	1.03	11.2	.900	14.6	.800	18.5	.720	22.9	.600	32.9	.514	44.9	.450	58.6	.400	74.2	.360	91.6	.327	111
3.0	.140	1.35	8.83	1.16	12.0	1.02	15.7	.905	19.8	.815	24.5	.679	35.3	.582	48.1	.509	62.8	.453	79.5	.407	98.2	.370	119
3.2	.160	1.52	9.42	1.31	12.8	1.14	16.7	1.02	21.2	.915	26.2	.763	37.7	.654	51.3	.572	67.0	.508	84.8	.458	105	.416	127
3.4	.180	1.70	10.0	1.46	13.6	1.27	17.8	1.13	22.5	1.02	27.8	.851	40.0	.729	54.5	.638	71.2	.567	90.1	.510	111	.464	134
3.6	.202	1.89	10.6	1.62	14.4	1.41	18.8	1.26	23.8	1.13	29.4	.943	42.4	.808	57.7	.707	75.4	.629	95.4	.566	118	.514	142
3.8	.225	2.08	11.2	1.78	15.2	1.56	19.9	1.39	25.2	1.25	31.0	1.04	44.7	.892	60.9	.780	79.6	.693	101	.624	124	.567	150
4.0	.250	2.28	11.8	1.96	16.0	1.71	20.9	1.52	26.5	1.37	32.7	1.14	47.1	.979	64.1	.856	83.7	.761	106	.685	131	.623	158
4.2	.275	2.49	12.3	2.14	16.8	1.87	22.0	1.66	27.8	1.50	34.3	1.25	49.5	1.07	67.3	.935	87.9	.832	111	.748	137	.680	166
4.4	.302	2.71	12.9	2.33	17.6	2.03	23.0	1.81	29.1	1.63	36.0	1.35	51.8	1.16	70.5	1.02	92.1	.905	116	.814	144	.740	174
4.6	.330	2.94	13.5	2.52	18.4	2.21	24.0	1.96	30.4	1.76	37.6	1.47	54.1	1.26	73.7	1.10	96.3	.981	122	.883	150	.803	182
4·8	.360	3.18	14.1	2.72	19.2	2.38	25.1	2.12	31.8	1.91	39.2	1.59	56.5	1.36	76.9	1.19	100	1.06	127	.954	157	.867	190
5.0	.390	3.43	14.7	2.94	20.0	2.57	26.2	2.28	33.1	2.05	40.9	1.71	58.9	1.47	80.2	1.28	105	1.14	132	1.03	163	.935	198
5.2	.422	3.68	15.3	3.15	20.8	2.76	27.2	2.45	34.4	2.21	42.5	1.84	61.2	1.58	83.3	1.38	109	1.23	138	1.10	170	1.00	206
5.4	.455	3.94	15.9	3.38	21.6	2.96	28.2	2.63	35.8	2.37	44.2	1.97	63.6	1.69	86.6	1.48	113	1.31	143	1.18	177	1.07	214
5.6	.490	4.22	16.5	3.61	22.4	3.16	29.3	2.81	37.1	2.53	45.8	2.11	65.9	1.81	89.8	1.58	117	1.40	148	1.26	183	1.15	222
5.8	.525	4.50	17.1	3.85	23.2	3.37	30.3	3.00	38.4	2.70	47.4	2.25	68.3	1.93	93.0	1.68	121	1.50	154	1.35	190	1.22	229
6.0	.562	4.78	17.7	4.10	24.0	3.59	31.4	3.19	39.7	2.87	49.0	2.39	70.7	2.05	96.2	1.79	125	1.59	159	1.43	196	1.30	237
6.2	.600	5.08	18.2	4.36	24.8	3.81	32.4	3.39	41.0	3.05	50.7	2.54	73.0	2.18	99.4	1.90	130	1.69	164	1.52	203	1.38	245
6.4	.640	5.39	18.8	4.62	25.6	4.04	33.5	3.59	42.4	3.23	52.3	2.69	75.4	2.31	102	2.02	134	1.79	169	1.61	209	1.47	253
6.6	.680	5.70	19.4	4.89	26.4	4.28	34.5	3.80	43.7	3.42	54.0	2.85	77,7	2.44	106	2.14	138	1.90	175	1.71	216	1.55	261
6.8	.722	6.02	20.0	5.16	27.3	4.52	35.6	4.01	45.0	3.61	55.6	3.01	80.1	2.58	109	2.26	142	2.01	180	1.81	222	1.64	269
7.0	.765	6.35	20.6	5.45	28.0	4.77	36.6	4.24	46.4	3.81	57.2	3.18	82.4	2.72	112	2.38	146	2.12	185	1.90	229	1.73	277

FRICTION OF WATER IN PIPES—*continued.*

Velocity of water, in feet per second.	Head to produce this velocity, in feet.	Internal diameter of pipe in inches.																							
		12		13		14		15		16		18		20		22		24		26		28		30	
		Head to over-come friction, in feet.	Cubic feet per minute.	Head to over-come friction, in feet.	Cubic feet per minute.	Head to over-come friction, in feet.	Cubic feet per minute.	Head to over-come friction, in feet.	Cubic feet per minute.	Head to over-come friction, in feet.	Cubic feet per minute.	Head to over-come friction, in feet.	Cubic feet per minute.	Head to over-come friction, in feet.	Cubic feet per minute.	Head to over-come friction, in feet.	Cubic feet per minute.	Head to over-come friction, in feet.	Cubic feet per minute.	Head to over-come friction, in feet.	Cubic feet per minute,	Head to over-come friction, in feet.	Cubic feet per minute.	Head to over-come friction, in feet.	Cubic feet per minute.
2·0	·062	·165	94·2	·152	110	·141	128	·132	147	·123	167	·110	212	·099	262	·090	316	·082	377	·076	442	·070	513	·066	589
2·2	·075	·195	103	·180	121	·167	141	·156	162	·146	184	·130	233	·117	288	·106	348	·097	414	·090	486	·083	564	·078	684
2·4	·090	·228	113	·210	133	·195	154	·182	176	·171	201	·152	254	·137	314	·124	380	·114	452	·105	531	·097	616	·091	707
2·6	·105	·263	122	·242	144	·225	167	·210	191	·197	218	·175	275	·158	340	·143	412	·131	490	·121	575	·112	667	·105	766
2·8	·122	·300	132	·277	156	·257	179	·240	206	·225	234	·200	297	·180	366	·164	443	·150	528	·138	619	·128	718	·120	824
3·0	·140	·339	141	·313	166	·291	198	·271	221	·255	251	·226	318	·204	393	·185	475	·170	565	·157	663	·145	770	·136	883
3·2	·160	·381	151	·352	177	·327	205	·305	235	·286	268	·254	339	·229	419	·208	507	·191	603	·176	708	·163	821	·152	942
3·4	·180	·425	160	·393	188	.365	218	·340	250	·319	284	·283	360	·255	445	·232	538	·213	641	·196	752	·182	872	·170	1001
3·6	·202	·472	169	·435	199	·404	231	·377	265	·354	301	·314	382	·283	471	·257	570	·236	678	·218	796	·202	923	·189	1060
3·8	·225	·520	179	·480	210	·446	243	·416	280	·390	318	·347	403	·312	497	·284	601	·260	716	·240	840	·223	974	·208	1119
4·0	·250	·571	188	·527	221	·489	256	·457	294	·428	335	·380	424	·342	523	·311	633	·285	754	·263	885	·244	1026	·228	1178
4·2	·275	·624	198	·576	232	·534	269	·499	309	·468	352	·416	445	·374	550	·340	665	·312	791	·288	929	·267	1077	·249	1237
4·4	·302	·679	207	·626	243	·582	282	·543	324	·509	368	·452	456	·407	576	·370	697	·339	829	·313	973	·290	1129	·271	1296
4·6	·330	·736	217	·679	254	·634	295	·589	339	·552	385	·490	488	·441	602	·401	728	·368	867	·339	1017	·315	1180	·294	1355
4·8	·360	·795	226	·734	265	·682	308	·636	353	·596	402	·530	509	·477	628	·434	760	·397	905	·367	1062	·341	1231	·318	1414
5·0	·390	·857	235	·791	276	·734	321	·685	368	·642	419	·571	530	·514	654	·467	792	·428	942	·395	1106	·367	1283	·343	1472
5·2	·422	·920	245	·850	287	·789	333	·736	383	·690	435	·614	551	·552	680	·502	823	·460	980	·425	1150	·394	1334	·368	1531
5·4	·455	·986	254	·910	298	·845	346	·789	397	·740	452	·657	572	·592	707	·538	855	·493	1018	·455	1194	·423	1385	·394	1590
5·6	·490	1·05	264	·973	309	·903	359	·843	412	·791	469	·703	534	·632	733	·575	887	·527	1055	·486	1239	·452	1437	·422	1649
5·8	·525	1·12	273	1·04	321	·964	372	·899	427	·843	486	·749	615	·674	759	·613	918	·562	1093	·519	1283	·482	1488	·450	1708
6·0	·562	1·19	283	1·10	332	1·02	385	·957	442	·897	502	·798	636	·718	785	·652	950	·598	1131	·552	1327	·513	1539	·478	1767
6·2	·600	1·27	292	1·17	343	1·09	397	1·01	456	·953	519	·847	657	·762	811	·693	982	·635	1168	·586	1371	·544	1590	·508	1826
6·4	·640	1·35	301	1·24	354	1·15	410	1·06	471	1·01	536	·898	678	·808	838	·735	1013	·673	1206	·622	1416	·577	1642	·539	1885
6·6	·680	1·42	311	1·31	365	1·22	423	1·14	486	1·07	553	·950	700	·855	864	·778	1045	·713	1244	·658	1460	·611	1693	·570	1943
6·8	·722	1·50	320	1·39	376	1·29	436	1·20	500	1·13	569	1·00	721	·904	890	·821	1077	·753	1282	·695	1504	·645	1744	·602	2003
7·0	·765	1·59	330	1·46	387	1·36	449	1·27	515	1·19	586	1·06	742	·953	916	·867	1109	·794	1319	·733	1548	·681	1796	·635	2061

WEIGHTS, OF 9 FEET LENGTH, OF FLANGED CAST-IRON PIPES OF VARIOUS DIAMETERS.

Diameter of Bore.	Thickness of metal.	Diameter of Flange.	Thickness of Flange.	Diameter of Circ. through Holes.	Diameter of Holes.	Number of Holes.	Weight.		
Inches.	Inches.	Inches.	Inches.	Inches.	Inches.		Cwt.	qr.	lbs.
2	3/8	6½	9/16	4¾	5/8	4	0	3	0
3	3/8	7½	5/8	6	5/8	4	1	0	3
4	½	9½	¾	7¾	¾	4	1	3	5
5	½	10½	7/8	8¾	¾	4	2	1	12
6	5/8	12	7/8	10	7/8	4	3	2	1
7	5/8	14	1	11¾	7/8	6	4	3	17
8	¾	15	1	12¾	1	6	5	2	9
9	¾	16½	1 1/16	14¼	1	6	6	1	12
10	¾	17½	1⅛	15½	1	6	7	0	0
11	7/8	19	1 3/16	16¾	1	6	8	3	24
12	7/8	20	1¼	17¾	1⅛	6	9	3	5
13	7/8	21	1¼	18¾	1⅛	6	10	2	0
14	7/8	22	1¼	19¾	1⅛	8	11	0	26
15	7/8	23	1¼	20¾	1⅛	8	12	0	25
16	7/8	24½	1 5/16	22	1¼	8	12	3	8
17	7/8	25½	1 5/16	23	1¼	8	13	2	17
18	1	26½	1⅜	24	1¼	8	16	1	15
19	1	28	1⅜	25	1⅜	8	17	2	13
20	1	29	1⅜	26	1⅜	8	18	0	26

TABLE

Showing the Quantity of Water per Linear Foot in Pumps or Vertical Pipes of different Diameters.

Diameter of Pump in inches.	Number of gallons per linear foot.	Number of cubic feet per linear foot.	Diameter of Pump in inches.	Number of gallons per linear foot.	Number of cubic feet per linear foot.
2	.136	.0218	8	2.176	.3490
2¼	.172	.0276	8¼	2 314	.3712
2½	.212	.0340	8½	2.456	.3940
2¾	.257	.0412	8¾	2.603	.4175
3	.306	.0490	9	2.754	.4417
3¼	.359	.0576	9¼	2.909	.4666
3½	.416	.0688	9½	3.068	.4923
3¾	.478	0766	9¾	3.232	.5184
4	.544	.0872	10	3.400	.5454
4¼	.614	.0985	10¼	3,572	.5730
4½	.688	.1104	10½	3.748	.6013
4¾	.767	.1230	10¾	3 929	.6302
5	.850	.1363	11	4.114	.6599
5¼	.937	.1503	11¼	4.303	.6902
5½	1.028	.1649	11½	4.496	.7212
5¾	1 124	.1803	11¾	4.694	.7529
6	1.224	.1963	12	4 896	.7853
6¼	1.328	.2130	12½	5.312	.8521
6½	1.436	.2304	13	5.746	.9217
6¾	1.549	.2489	13½	6.196	.9939
7	1.666	.2672	14	6.664	1.0689
7¼	1.787	.2866	15	7.650	1.2271
7½	1.912	.3067	16	8.704	1.3962
7¾	2.042	.3275	18	11.016	1.7670

CAST-IRON PIPES, HOLLOW COLUMNS, OR CYLINDERS.

WEIGHT PER LINEAL FOOT.

Diameter of Bore.	¼ inch thick.	⅜ inch thick.	½ inch thick.	⅝ inch thick.	¾ inch thick.	⅞ inch thick.	1 inch thick.	1⅛ inch thick.	1¼ inches thick.
in.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
1	3·06	5.06	7·36	9·97	12·89	16·11	19·63	..	..
1¼	3·68	5·98	8·59	11·51	14·73	18·25	22·09	..	..
1½	4·29	6·9	9·82	13·04	16·56	20·4	24·54	..	..
1¾	4·91	7·83	11·05	14·57	18·41	22·55	27·	..	..
2	5·53	8·75	12·25	16·11	20·25	24·7	29·45	..	..
2¼	6·14	9·66	13·5	17·64	22·09	26·84	31·85	..	...
2½	6·74	10·58	14·72	19·17	23·92	28·93	34·36	..	..
2¾	7·36	11·5	15·95	20·7	25·71	31·14	36·81	..	..
3	7·98	12·43	17·18	22·19	27·62	33·29	39·25	45·56	52·28
3¼	8·59	13·34	18·35	23·78	29·45	35·44	41·72	48·32	55·22
3½	9·2	14·21	19·64	25·31	31·3	37·58	44·18	51·08	58·29
3¾	9·76	15·19	20·86	26·85	33·13	39·73	46·63	53·84	61·36
4	10·44	16·11	22·1	28·38	34·98	41·88	49·	56·61	64·25
4¼	11·1	17·08	23·37	29·97	36·87	44·08	51·6	59·42	67·45
4½	11·66	17·94	24·54	31·44	38·65	46·17	53·99	62·12	70·56
4¾	12·27	18·87	25·77	32·98	40·5	48·32	56·45	64·89	73·63
5	12·88	19·78	27·	34·51	42·25	50·46	58·9	67·64	76·25
5¼	13·5	20·71	28·23	36·05	44·18	52·62	61·36	70·41	79·77
5½	14·11	21·63	29·45	37·58	46·02	54·76	63·81	73·17	82·84
5¾	14·73	22·55	30·68	39·12	47·86	56·91	66·27	75·94	85·91
6	15·34	23·47	31·9	40·65	49·50	59·06	68·5	78.74	89·
7	17·79	27·15	36·8	46·79	56·84	67·65	78·5	89·7	101·25
8	20·02	30·83	41·7	52·92	64·42	76·23	88·25	100·78	114·
9	22·71	34·52	46·5	59·07	71·5	84·84	98·5	111·84	126·
10	25·16	38·2	51·5	65·2	79·16	93·42	108·	122·87	138·
11	27·62	41·88	56·25	71·33	86·5	102·01	117·5	133·92	150·3
12	30·06	45·55	61·	77·46	93·6	110·6	127·25	144·96	163·
14	..	..	..	90·6	109·6	129·	148·8	168·7	189·
16	..	..	..	..	124·5	146·4	168·6	181·2	213·8
18	..	..	..	..	139·4	163·7	188·4	213·3	238·5
20	..	..	..	..	152·5	181·1	208·2	235·6	263·3
24	..	..	..	..	182·	213·3	247·9	280·2	312·9
28	..	..	..	..	213·	237·4	286·	321·3	360·
30	..	..	..	..	227·	264·7	305·	343·2	384·
34	..	..	..	..	257·	299·	845·	387·3	443·

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